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REGIA
MONACENSIS.

GEOLOGY

OF

NEW-YORK.

PART I.

COMPRISING THE

GEOLOGY OF THE FIRST GEOLOGICAL DISTRICT.

BY WILLIAM W. MATHER,

Professor of Natural History in the Ohio University.

ALBANY:

PRINTED BY CARROLL & COOK, PRINTERS TO THE ASSEMBLY.

.....

1843.

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SAMUEL YOUNG,

Secretary of State.

Albany, 1842.

TO HIS EXCELLENCY

WILLIAM H. SEWARD,

GOVERNOR OF NEW-YORK.

SIR:

I have the honor to submit herewith the Report of the First Geological District of the State of New-York.

I have the honor to remain,

Your obedient servant,

W. W. MATHER,

Geologist of the First District

OAKLAND, Jackson County, Ohio,
July 1, 1842.

PREFACE.

The readers of this work will observe that some new and modified views of geological phenomena have been introduced. This has not been from any desire of novelty or notoriety, but with a conviction that they explain more satisfactorily the geological problems with which they are connected, and with a sincere desire to attain to a knowledge of truth in the works of nature. The facts now known are believed to be sufficient to render the conclusions highly probable. Investigations will be made by others to test the facts and conclusions, and I trust this work may aid in throwing light on some of the physical causes of geological phenomena, and lead to a solution of some of the problems of geology. It is scarcely possible that the conclusions arrived at from a review of the various facts adduced and known, will stand the test of time unmodified; as almost all the theories that have heretofore been given, have been found imperfect or erroneous as knowledge of the earth's structure has progressed. The evidences are often imperfect or local, and often those parts of the country, continent, hemisphere, or of the earth where the decisive evidence rests, remain either unexplored, or have been so slightly examined as to afford nothing satisfactory. I have no theoretical hobby to maintain, and have been uninfluenced by any theories of others.

The views of one of my colleagues are different on some of the problems of geology, as I have just learned by seeing his published works. Time will determine who is right; and the author, if wrong, will, without hesitation, yield the point. Prof. E. Emmons has discussed the long and still vexed question of the age of the Taconic rocks (the peculiar slates, limestones, etc. along the eastern line of New-York, from Lake Champlain to the Highlands). He has the advantage of having lived on and among them, and of exploring them with much minuteness during many years, and probably every geologist from examining them where he has, would arrive at the same conclusion as to their age. He admits

that they are not found at any locality resting upon the Primary, but that the Potsdam sandstone is the lowest known rock resting upon that formation. The Taconic rocks are not found in the district that he had for examination, (2d Geol. district) and he has not, therefore, examined them as *extensively* as it has been my duty to do. They are found in New-York only in the First Geological District.

Prof. Hitchcock, the geologist of Massachusetts, has also entered into a discussion of the age of the Taconic rocks, as they occupy some space in the western part of Massachusetts. His observations, and those of Prof. Dana, have long since drawn the attention of geologists to these rocks. Prof. Hitchcock has examined them with much minuteness in Massachusetts; and his observations, and those of the Profs. Rogers of Pennsylvania and Virginia, have led to some conclusions that tend greatly to exalt our ideas of the grandeur and great power of the physical causes of geological effects, and his conclusions seem to be warranted by the facts. Prof. Hitchcock views these rocks as metamorphic, a conclusion entirely opposite to that of Prof. Emmons; but he could find no data from which to infer their age and place in the geological series. Both these gentlemen, Profs. H. D. and W. B. Rogers, and various other geologists, have come to the conclusion that these rocks, and in fact most of those from the Hoosick mountain range to the Hudson, have been wrinkled up and folded over, all in one direction, so as to give the same direction of dip; and I concur with them in this opinion.

My own observations on these rocks and those of the Hudson valley, conducted with much care through their whole extent in New-York, and in Vermont and Massachusetts, through a series of years, have led me to the conclusion that they are metamorphic, and of the age of the Champlain division; that they are the altered limestones, slates and sandstones of that division. The evidences are adduced in the following work.

The white limestone containing plumbago and various crystallized minerals, is another point on which there are various views. I have come to the conclusion that it is metamorphic, but in a more highly metamorphic state than the dolomitic limestones of the Taconic rocks. The facts in evidence are adduced.

In studying the geology of this continent, both from the labors of others and personal observation, I have thought I recognized a great physical law sufficient to explain the deposition and distribution of all the sedimentary rocks from the oldest transition to the latest quaternary formations,; a law that still acts, and may be expected through all time to come to produce similar effects in the ocean, to those we have evidence of its having produced in times past. The discussion

will be found to commence in the *Quaternary formation*, more fully entered into in the *Drift deposits*, and more or less continued through the *Upper secondary*, *Coal* and other *Fossiliferous* and *Sedimentary strata* to the Potsdam sandstone. At the meeting of the Association of American Geologists at Philadelphia in 1840, I was appointed to make a commuuication at the next annual meeting, on the "*Drift*." At the next meeting the labor taken in hand was not completed, but a glimpse of light was believed to have been perceived that would lead to an explanation of the phenomena of the "Drift." Leave was asked and obtained to defer the communication another year. Unexpectedly to me, I could not attend the two next succeeding meetings, and the paper on "*Drift*" intended to have been brought before the Association in 1842, but enlarged and more fully discussed, now first comes before the public in this work. Numerous facts in detail are introduced to show the grounds for the conclusions, some of which are believed to be different from any that have been broached. Time and investigation will show whether they are well founded. Nearly all the phenomena of physical geology may, it is believed, be referred to the effects of three causes, viz: 1. Caloric; 2. Gravitation; 3. Centrifugal force of the earth revolving on its axis.

The explanations of blowing caves and of ebbing and flowing springs, are original and believed to be new. Various subjects are discussed under new points of view, but to which it is unnecessary to call the attention, as those who would be interested in such things will necessarily find them.

To Mr. PATTERSON, the careful proof reader, I here return my thanks. He has relieved me from almost the entire labor of corrections. It is only by an accurate knowledge of the subject, and great and continued vigilance and care that the work could have gone through the press with so few errors.

While engaged in the operations of the geological survey of New-York, I have met with cordial coöperation every where, among all classes of the community, and but a single isolated instance has occurred where we were molested in our labors, and that through ignorance.* It would be invidious to mention a few of the gentlemen who have aided us by their local knowledge of facts and phenomena, where so *many* are entitled to our thanks.

---

*This was while procuring specimens from a boulder on Long Island, that had been removed from a field of the adjoining farm into the road. The owner, thinking there must be gold in the stone, from our preserving the specimens with so much care, and wrapping them in papers, directed the collectors to desist; but as it was in a public road, we declined to do so.

The following gentlemen have been engaged with me as regular assistants on the geological survey, viz: Dr. WILLIAM HORTON, of Orange county; Professor L. D. GALE, of New-York University; Professor J. L. CASSELS, of the Willoughby Medical College; Professor F. MERRICK, of the Ohio University; Professor C. BRIGGS, of the Rensselaer Institute; J. GEBHARD junior, esquire, of Schoharie; Cadet T. SEYMOUR, United States Military Academy; and Mr. HENRY GREEN, of Albany; and I here tender them my thanks for their assistance, and my hopes that they may continue to aid in developing the resources of our country, and the wonderful works of our Creator.

The State of New-York is the first that has fully carried out the principle of division of labor in the execution of a survey on the Natural History of the State, under the name of a geological survey. By this arrangement each head of a department of the survey has been enabled to devote his whole time and attention to his own specific duties, without having the entire range of natural science to distract his attention.

The survey of New-York, unlike that of some of the other states, has been uninfluenced by party and political considerations, and the chief magistrates, during its execution, have been actuated by high and ennobling motives. I here tender to Ex-Governors WILLIAM L. MARCY and WILLIAM H. SEWARD my sincere thanks for their continued kindness, and for the warm interest they have continually manifested for the successful accomplishment of the survey.

I now commit this work to the public, with the hope that it may be useful in developing the resources of the State and of our country; that it may lead many to a contemplation of the wonderful works of our Creator, and exalt their minds from nature up to nature's God.

W. W. MATHER.

OHIO UNIVERSITY, ATHENS, OHIO,
September 1, 1843.

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REPORT

OF THE

SURVEY OF THE FIRST GEOLOGICAL DISTRICT.

CHAPTER I.

INTRODUCTION.

In developing the geology of the First District of New-York, I have made such progress as my opportunities have permitted; and although little has been accomplished, when compared with what remains open for investigation, the results of these labors may be of some value to the community, as tending to make known the nature of the materials on a small portion of our planet, their position, uses, relative ages, and some of the various physical changes that this portion of the earth's surface has undergone.

The labor of investigating the rocks in the first district is much greater than in the others, in consequence of their having been broken up by some convulsive action, and turned edgewise through extensive tracts of country, like ice, where broad fields of it crush against each other. This may seem visionary to those who have not investigated the facts of geology; but all can examine the facts in evidence, and draw their own conclusions.

The First Geological District embraces twenty-one counties, and extends from the north end of Washington county between Lakes Champlain and George, southwestwardly to the Susquehannah river; so as to include the counties of Washington, Saratoga, Schenectady, Schoharie, Delaware, and all east and south of this line that lie within the limits of the State of New-York.

The rock formations of the First Geological District may be arranged in the following order as great masses, viz:

1. Quaternary System. { Alluvial division. / Quaternary division. / Drift division.
2. Tertiary System.
3. Trappean System.
4. Redsandstone System.
5. Coal System.
6. New-York System. { Catskill division. / Erie division. / Helderberg division. { Corniferous limestone, Onondaga limestone, Schoharie grit, Cauda-galli grit, Oriskany sandstone, Catskill shaly limestone, Pentamerus limestone, Water-lime group, Onondaga salt group. / Ontario division. Oneida or Shawangunk conglomerate. / Champlain division. { Hudson River group, Utica slate, Trenton limestone, Calciferous group, Potsdam sandstone.
7. Taconic System.
8. Primary System. { Metamorphic rocks. / Primary rocks.

The Quaternary system, including also the alluvial and drift, occupies the whole of Long Island, except a small area near Hurlgate; most of Staten Island; the flats and elevated plains of the Hudson and its tributaries; those of Wood creek, the Delaware, and some on the Susquehannah. It also occurs in many of the high valleys of the Highlands, the Catskills, and other elevated regions of the first district.

The *Tertiary* is found in some parts of Long Island.

The *Trappean rocks* are mostly confined to Rockland county, and the most prominent mass is that called the *Palisades*. Dykes, veins and injected and protruded masses of rock belonging to this system, occur more or less in the primary region.

The *Redsandstone* of the Hudson, in the first district, is entirely confined to Rockland and Richmond counties, but ranges southward into New-Jersey.

The *Coal formation* exists in only a few small patches in Greene and Sullivan counties, and it is believed to contain no workable coal.

The *New-York system* underlies all the area from the primary and metamorphic ranges of rocks on the east and north, to the western limits of the first district; and thence extends northwest, west and southwest, under all the country from the Blue Ridge to the Rocky Mountains, and from Alabama to Lake Superior; and to the primary range that crosses the country westward from Lake Superior, above the Falls of St. Anthony, and the mouth of the Aux Liard on the St. Peter's river. I have examined this formation more or less extensively at frequent intervals, over nearly all of this area. About fifty thousand square miles of it are covered by the great coal formation that occupies the northeast and western parts of Pennsylvania, the western parts of Maryland and Virginia, a portion of Tennessee and Alabama,

and the eastern parts of Kentucky and Ohio. Another great coal formation covers this system over most parts of the Green River valley in Kentucky, and the Wabash valley in Illinois, and is perhaps connected with the coal formations of the Kaskaskia, Illinois, Rock river, and Mississippi about St. Louis. Another coal formation covers these rocks in Michigan, extending from Saginaw bay south-southwest, as we learn from Dr. Houghton, the Geologist of Michigan. This coal formation was not known until the researches of the Geological Survey of Michigan were in progress. Another coal formation covers the New-York system of rocks in the southwest part of Missouri, and in the Choctaw, Cherokee, and Creek country west of Arkansas; on the Arkansas and some of its tributaries, and on that spur of the Rocky mountains between the Red river and the Arkansas. This formation does not extend within the limits of Arkansas, so far as I know, unless at its northwest corner.

The Cretaceous formation also covers extensive areas of the New-York system of rocks on the Red river, the Arkansas and Missouri, and their tributaries, where they have been examined by Dr. Pitcher, Mr. Nicollai, Mr. Featherstonhaugh, myself and others.

The New-York system of rocks includes the Cambrian and Silurian systems of Murchison; and as these rocks in North America are so much more extensively developed than in Europe, and are so situated that their order of superposition can be easily determined, and contain many more genera and species of fossils than the equivalent European rocks; and as we have here many strata that are absent in the Cambrian and Silurian systems, the geographical name of *New-York System* has been adopted as appropriate, and as one that will make no difficulty in determining geological equivalents.

The Taconic System. This includes rocks between the Primary and Potsdam sandstone, and metamorphic rocks, and occurs more or less extensively developed along the western boundary of the Highland primary range.

The Primary system occupies a small portion of Long and Staten Islands; forms most of the small islands belonging to New-York, in the west part of Long Island Sound, all of New-York island, Westchester county, the Highlands, their continuation along the east line of the State to Massachusetts, and the mountainous parts of Saratoga and Washington counties. There are also some isolated masses of primary rocks, like islands, surrounded by other rocks.

CHAPTER II.

QUATERNARY SYSTEM.

PRELIMINARY REMARKS.

This system is intended to embrace the alluvial, and all those accumulations of matter above the newer tertiary. It is necessary to adopt this grouping, in consequence of the absence of organic remains, and all other sources from which specific distinctions can be drawn. The differences of age and circumstances of deposition are evident, and these deposits will be discussed as far as practicable in their natural order under the following divisions, viz:

1. Alluvial Division;
2. Quaternary Division;
3. Drift Division.

1. ALLUVIAL DIVISION.

These alluvial deposits are in constant process of formation, by a great variety of causes in action at the present time.

The phenomena of the alluvial deposits of the district are of much practical importance to the State, as they increase or lessen the value of particular situations. The phenomena of land-slides, sand-dunes, or hills of drifting sands; the formation of peat, shell-marl, bog iron-ore, and tufa deposits from springs; the washing away of the land so as to form banks, bars and shoals in our rivers and bays, and along our coast, are the most important.

Alluvial deposits open one of the most interesting and important fields of geological research. In them we study present causes, and are enabled to investigate all those natural changes which are *now* in progress, and which serve to modify the present surface of the earth. They also enable us to trace the action of similar causes in former times, when the most of the rocks with which we are acquainted were formed.

Fluviatile Alluvions.

In the Hudson are many alluvial islands between the mouth of the Mohawk and Catskill. These islands, and the sandbars and mud-flats, have been increasing in elevation and extent

much more rapidly for a few years past, than at any former period since observations have been made. This is caused principally by the increased quantity of land brought under tillage, and from which every shower removes more or less earthy materials in the streams, far more than when the soil was covered by its native forests. The small streams deposit the greater portion of the coarser earthy materials washed into them; but much of the finer portions is carried in suspension into the Hudson, and finally deposited more or less remote from its source. The coarser materials washed down the Hudson are deposited at and near the Overslaugh, where the river current is checked in ordinary stages of the river by the flood-tide. It is only during freshets, that the river current is sufficient to overcome the tidal flow, so as to carry its coarse alluvion farther down the stream. This has caused serious obstruction to navigation in time of low water in summer and autumn, and science and art have been put in requisition to overcome this natural impediment to navigation. Large sums of money have been expended to make a channel of sufficient width and depth to accommodate the various interests concerned in the navigation of the river, and keep it open. The best means have been employed to obviate the difficulty, and the system employed is the only one that would be permanently useful; but it must be kept constantly in operation, the piers elongated every few years, and a dredging machine frequently employed in seasons when the river is very low. In low water, sand accumulates between the piers; and in a higher stage of water, much of the sand is washed through the channel, and deposited in the eddies and still water beyond them; so that in places where the water was before of considerable depth, sandbars and shoals form, and eventually obstruct the navigation. The dredging machine or an elongation of the piers then becomes necessary, so as either to deepen the channel, or cause an acceleration of the current to effect the same object. Large quantities of additional matter, in the form of sand and mud, are continually washed down the river from above; so that the difficulty is a permanent one, and will continue as long as fields are cultivated and water flows. A permanent fund ought to be established to provide for the necessary annual dredging, and the occasional elongation of the piers.

The soils of the flats and islands in the Mohawk valley, and in that of the Hudson below Lansingburgh, have long been celebrated for their fertility. They all contain some lime mixed with argillo-siliceous and organic matter.

The alluvions of the Hoosick are similar to those of the Mohawk, in consequence of the water flowing for a considerable distance over argillaceous and calcareous rocks, which are similar in composition to those of the Mohawk.

The alluvial deposits of the Batten kill are much smaller, and not as good soil as the others. These alluvions are more siliceous, in consequence of the great quantity of siliceous gravel, pebbles, and boulders of granular quartz, brought down from the Green mountains during freshets. There is a striking difference in the productiveness of the alluvions of the Batten kill in the eastern part of Washington county, and those of the neighboring small streams that flow over and derive their alluvial materials from the argillaceous and argillo-calcareous rocks of this part of the same county. The Batten kill alluvions of this part of its course are mostly formed of sand, gravel and pebbles, derived from the granular quartz of the Green

mountains. This fact may be seen well illustrated about two miles from Salem, on the road to Cambridge, where the alluvions of Black creek and White creek mingle with that of the Batten kill; and it was observed that the alluvion of this last stream was much less productive than the others, although at a little distance they appeared to be as good lands.

The alluvions of Wood creek are very productive, but have little extent above its delta in Lake Champlain. They are derived from slate, limestone, sandstone, granitic and gneissoid rocks, and the soils resulting might be inferred to be highly productive. The alluvion of the valley at the junction of Pawlet river with Wood creek, has a width of a mile, and in several places on these streams it has a breadth of one-half mile.

Whitehall is usually called the head of Lake Champlain, but the lake for fifteen miles is rarely more than one hundred to one hundred and fifty yards wide. It is in fact a mere channel between mud-flats of clayey alluvion, that form the delta of Wood creek, Pawlet river and Poulteny river.* In several places the channel is divided into two or three, by alluvial ooze islands and shoals of recent origin. They are generally covered only by aquatic plants, as rushes, flags, lily pads, wild rice, coarse grass, bushes and small trees. One of the marshes is called *Twelve-mile marsh*, in consequence of its length, extending from South bay twelve miles down the lake. This marsh has the same vegetable covering as the islands above described, except that bushes and trees are rarely seen.

The lake is skirted in many places between Whitehall and the north end of Twelve-mile marsh, by a clay formation similar to that of the Hudson valley. This formation is elevated from thirty to sixty feet above the lake, and a small portion of the alluvion of this part of the lake is derived from the wash of the rivulets, and encroachment of the lake on this formation; but the effects produced by these causes are small indeed, when compared with the earthy materials brought down by Wood, Pawlet and Poulteny creeks. From Whitehall to near the end of Twelve-mile marsh, the channel of the lake is not generally more than one hundred yards wide, and a sensible current flows through it. The channel is bounded on each side for a great portion of this distance by mud-flats and marshes that are often overflowed, either in consequence of freshets in the creeks mentioned, or of strong or long continued north winds, which raise the water at the south end of the lake. The channel may be considered as an extension of Wood creek flowing through its delta.

Some of the alluvial flats and marshes of this part of Lake Champlain are already used for grazing cattle, and a coarse hay is cut on some others. It is believed that many of these lands will, before many years, be diked out to guard against their being overflowed, and then they will make most highly productive lands for tillage and hay.†

It is well known that large portions of Holland are thus redeemed from the dominion of the sea. Small tracts of a few hundred to a few thousand acres have also been diked out on our

* These rivers are not of such size as to justify the name; they are creeks, from one to four or five rods wide.

† A strong north wind, or a more moderate one of some days' continuance, raises the water a foot or more above its medium level; and one from the opposite point of the compass would depress it as much below its medium level, so that dykes are necessary to protect the flats from occasional inundation.

own coast, and on the Hudson, where they would otherwise be periodically inundated by the spring tides.

The soils along the Hudson, and its tributaries, are more or less clayey, and large quantities of the muddy alluvions are brought into it and deposited. Almost every creek entering the Hudson has its delta. These alluvions are numerous and highly important, both in a scientific and economical point of view. They are sensibly increasing in height and area in many localities, and will, at some future time, make valuable and productive lands. Many of them are now employed for hay and pasturage, and others are rapidly becoming adapted for such uses.

The materials of the Hudson river alluvions are almost entirely composed of ooze, sand and fine silt, mixed with the remains of organic matter. These alluvions are formed wherever eddies occur, caused by a change of the general direction of the current, by islands, bars, shoals, or even small obstacles, like sunken logs, trees and rocks. The current, sweeping by these obstacles, circles around in an eddy, and the materials in suspension settle to the bottom. Small obstacles, as logs or rocks, are known to have thus served as the nuclei of islands. Such deposits, when covered by a depth of a few feet of water, support a great growth of aquatic plants, which entangle much of the sedimentary matter of the water, and by their own decay serve to increase the accumulating deposit. The shoal, on reaching the surface, supports a heavier growth of vegetable matter, which serves to increase the deposit in a sensible degree. One who has not examined the dense mass of vegetation on some of these alluvions, can scarcely appreciate the effects of this cause.

There are two islands of alluvial ooze opposite the upper part of Stuyvesant's; the larger one is nearly three miles long. An alluvial flat a mile and a half long, and on which a light-house is erected, extends from Kinderhook new steamboat landing to above the lower end of the large island just mentioned: it may be considered the delta of the creek, at the mouth of which it is located.

A marsh of fluviatile alluvion extends from Great Nutten or Neuten hook to Stockport landing. Great and Little Nutten hooks were once islands, which are now connected with the main land by the marsh. This marsh may be considered as the delta of the small creek which has its mouth between Great and Little Nutten hooks, and which has also received large accessions from the detrital matter brought into the Hudson by Kinderhook creek, and swept up by the tide. The mouth of Kinderhook creek is so located, that a delta of any magnitude cannot be formed there. The tidal currents sweep past it, and always press upon the shore of the Hudson both above and below. A small marsh, and two or three small bars are formed at and in the mouth of this creek; but most of its alluvion is swept down, or up the river, and deposited in situations more or less remote.

Opposite Hudson, there is an island of alluvial ooze of a mile or more in length; a canal has been cut across it, through which the ferry boats pass from Hudson to Athens.

A large marsh of ooze between Hudson and Merino mountain, is the proper delta of the creek which empties into the small bay below Hudson. From the north end of Merino mountain to the lower end of Rogers' island, is an extensive marsh of several hundred acres of

alluvial ooze. It is used for pasturage. There are boulders of rock on it, left by the ice, by which they were transported. A part of this marsh is covered by such trees as grow in our swamps.

Between Rogers' island and Catskill is an island of alluvial ooze, covered with tall grass, or a plant which is believed to be the wild rice of our northern lakes. It grows on some of the ooze islands and mud banks eight to ten feet high. From Oak-hill ferry, an alluvial ooze bank or flat, but which rarely shows itself above water, extends eight to nine miles down the river.

At the mouth of Livingston creek, which is also called Ancram creek, and Roeleff Jansen's creek, the alluvion is coarser (fine sand and silt), and covered with reeds and aquatic plants. This delta is the largest on this part of the Hudson. Opposite the lower part of Germantown, this deposit of alluvial forms long spits, almost islands, connected with the land at one end by very shoal water, while elsewhere they are separated by pockets of very deep water. The plant, believed to be the wild rice, grows very tall on these ooze spits.

Between Upper Redhook landing and the mouth of the Saghkill, an extensive alluvial deposit is forming, which may be considered as the united deltas of the Saghkill and the creek which empties into the Hudson southeast of Upper Redhook landing. The bay in which this deposition is taking place, is filling up by the deposits of the streams which flow into it, the wash of the adjacent clay hills on the east and north, and by organic depositions, which form a large proportion of the bulk of the accumulating matter. The aquatic plants grow very thick and luxuriantly, and by their annual decay form a large amount of carbonaceous matter, mixed with the wash of the adjacent country. Two islands cut off the river from most of the west boundary of this bay, and a marsh connects the largest island, or peninsula, with the main land, so that the water stagnates. These flats, of which there are some hundred acres, will eventually be valuable land; but several generations may pass away before that time, unless they be diked out. The islands are on a line with the rocky shore above Upper Redhook landing, and are the outcropping edges of the same strata.

An island of alluvial ooze is forming about two and a half miles below Rhinebeck landing, and extensive flats under water are also in process of formation. Between Emmet's and Thompson's landings, clay hills bound the bay on the east, in which these depositions are taking place. Three small creeks also empty into it, and by their deposits assist in the accumulation.

At the mouth of Caspar creek, a small delta is forming.

At the mouth of Wappinger's creek, a small alluvial deposition commences, which extends, with little interruption, until it joins that of Fishkill creek, and continues thence to the Highlands. There are few places where it shows itself above water, even at ebb tide; but it is an alluvial bank from fifty to six hundred yards broad, and nearly ten miles in length.

There are many small alluvial marshes and flats, which are too small to notice, and they can be of comparatively little value, even prospectively, except for manure. The river ooze is every where well adapted for fertilizing the soil.

The main object in introducing the subject of these alluvions, is their prospective value as land, capable of tillage, by diking them out, where the value of land and the small expense of diking will justify the change. Some of these alluvions, if reclaimed and tilled, would benefit the health of the adjacent country. Where the water stagnates on them, bilious, intermittent and remittent fevers are produced.

The flats at the mouths of the Rondout, Esopus, Catskill and Norman's kill, and Murderer's creek in Newburgh bay, are of some extent, as are those forming in Tappan bay between Sing-Sing and Dobbs' ferry; the meadows near Gen. Van Cortland's, at the mouth of the Croton river; the mud and silt banks extending from the above mentioned meadows to Teller's point on one side and Sing-Sing on the other, and which occupy most of the bay between Teller's point and Sing-Sing; the flats in Haverstraw bay, between Teller's point and Verplanck; the meadows east of Verplanck; the flats between Verplanck and Roya hook, in Peekskill bay; the meadows between Anthony's Nose and Marble point, and the meadows and flats that lie southeast, east, northeast and north of Constitution island, below Coldspring. The last meadow is the only one that has been diked out, to prevent its being overflowed by the tides. Two or three hundred acres are enclosed, and good hay is produced upon these meadows. The meadow east of Verplanck may be said to be diked out. A fine road has been built across the marsh near its south end within the last two years, and the tide may now be excluded. The amount of drainage water flowing into it is very trifling.

This meadow is filled with peat to a great depth. While the road was in progress of construction across this quaking bog, the weight of gravel was so great as to cause the turf to yield, and the road sunk, while a mass of peat was forced up on each side, rising above the general level of the marsh. Several thousand loads of gravel were necessary to fill a small portion of the roadway that sunk, and it was estimated that the depth of the peat must have been about forty feet. The peat seen at this place, and which had been raised above the surface by the sinking of the roadway, was of inferior quality, coarse and fibrous, but that which is good may be below. This marsh is so convenient to water transport, that the peat may be considered valuable.

Peat is probably abundant in the meadows near Constitution island, though it has not been particularly examined.

The mud-flats that have been mentioned in Tappan bay, Haverstraw bay, Peekskill bay, and near Constitution island, are all increasing slowly, and from a variety of causes, such as vegetable decomposition, the silt and mud deposited from the water, and the growth and decay of molluscous and other animals. They have increased more rapidly during the last twenty years than before, in consequence of the greater amount of cultivated land causing a greater amount of earthy materials to be transported by the rains and surface waters into the Hudson. These flats will eventually become meadows, but the time may be far distant.

The flats along the right bank of the Hudson, opposite West-Point, both below Gee's point and near Camptown, have grown sensibly more shallow within the last fifteen years, during which time they have been under my observation. The same may be said of the flats between

Constitution island and Gouverneur's landing, opposite West-Point, and between Constitution island and Coldspring.*

A large portion of the low lands along the rivers, creeks and smaller streams, which are so generally celebrated for their fertility, and which vary in texture from clay through loam and sand, to gravel and pebble beds, belong also to fluviatile alluvions. The most extensive deposits of this class, are those on the Walkill, extending from below Springtown, by that village and New-Paltz, to near Libertyville; those of the Rondout river, near Rochester, Wawarsing and Ellenville; those of the Esopus creek, from Marbletown, by Hurley and Kingston, to near the Esopus falls; those of the Catskill and Katerskill creeks; and the Schoharie flats, which extend, with slight interruptions, from the mouth of Kripplebush kill, by the villages of Central-bridge, Schoharie and Middleburgh-bridge, to four or five miles above the latter place.

Lacustrine and Marsh Alluvions.

These are formed by the combined effects of the growth and decay of organic matter, and the deposits of the waters from the adjacent country flowing through them. The nature of the materials forming these alluvions varies much, according to local causes. If the water flowing into lakes or marshes with a gentle current be loaded with earthy matter, the ooze (or muck, as it is frequently called by our farmers,) will probably predominate. When the soils contain much lime, or if calcareous springs occur in the vicinity, fresh water mollusca will probably exist in quantities, and cause the deposition of shell marl; if neither of these causes should predominate, vegetable matter will accumulate so as to form peat.

Shell or Lake Marl. This deposit, so very useful on many soils as a manure, is continually forming. It is abundant in some parts of the district, more particularly in that which forms the valley of the Hudson. It occurs in those ponds, swamps and meadows which are fed by springs containing lime, or which serve as receptacles for the surface waters flowing over calcareous materials. It is a matter of common notoriety, that shells are very thin, and not abundant, in waters containing little calcareous matter. Almost all soils contain a little carbonate, sulphate or muriate of lime, some of which is carried by the surface and spring waters into marshes, rivers, lakes, etc. The calcareous matter is there absorbed and secreted by the testaceous animals, so as to form an external covering for their protection; but in those situations where little calcareous matter is furnished, the shells do not accumulate so as to form shell marl, because the testacea of each succeeding generation, in forming their own shells, consume those of preëxisting ones.

Where calcareous matter is abundant in water, testaceous animals secrete enough from their food to form their shells, without the necessity of consuming the dead ones of preceding generations, which often accumulate in so great quantities as to form thick and extensive beds of

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* In 1822, sloops used to come in at the foundry dock, about half way between Coldspring and the West-Point foundry, to take in their freight of cannon and other castings; but the water has become so shoal that for some years past it has not been possible, and they now load at Coldspring.

marl. Shell marl is a white pulverulent substance when dry; and when wet, is so soft that a pole may be easily thrust into it. It is composed of the shells and decayed fragments of the Lymnæa, Physa heterostropha, Planorbis trivolvis, P. campanulatus, Cyclas similis, and some other species. Uniones and anodontæ are sometimes found in it.*

Many of the beds of shell marl are covered by beds of peat from two to ten feet thick. Such localities were once lakes or ponds, which have been gradually filled up with alluvial depositions, and become land. The marl, if present, may be found by thrusting a pole through the mud into the stratum below; on withdrawing it, the marl may be recognized as a white slimy mud on the lower part of the pole, more or less concealed by the black mud through which it has been withdrawn. In some parts of Orange and Dutchess counties, this marl is much used by the farmers, and with great advantage to their crops. It is also used some in other counties along the Hudson, but its value is not yet fully appreciated. It is desirable that agriculturists should make more extensive use of a manure so valuable as this, on soils that contain little lime. This mineral may also be used, when pure, for whiting, and for making lime.

The value of fresh-water shell-marl is well known to our intelligent farmers; but few know it when they see it, and still fewer know in what situations to seek it. For these reasons, I have particularized its characters, its situations, and some of its localities, in the table of localities of marl and peat. It performs the same office on the land as air-slaked lime, and is as valuable a manure, while it has not its causticity to injure vegetation. One object in burning lime for land is, to reduce it to the state of powder by slaking. The shell-marl is already in a pulverulent state, and only requires to be dug from the swamps and ponds and spread on the land.

It is supposed that the localities mentioned in the table do not embrace one-half of the quantity of this shell-marl in the counties along the Hudson above the Highlands, and it is probable that it may be found in every township. The extent of country which it was necessary for us to examine, in order to accomplish the geological survey in the time contemplated by the Legislature, rendered it impossible to visit, much less to examine, more than a small part of the localities where various useful materials might be expected to occur.

The shell-marl may be used to replace gypsum, or at least a part of it, of which there is a great consumption. Gypsum has been invaluable to the lands of the counties above the Highlands, and it is probable that the shell-marl deposits will be of as great a value to the farming interests. It is estimated that the quantity of gypsum consumed annually in Columbia and Dutchess counties, amounts to from 15,000 to 30,000 tons. This is imported from Nova-Scotia, and delivered at the wharves on the Hudson river at about five dollars per ton. Allowing the consumption at 20,000 tons, the sum expended annually, exclusive of that for interior transportation, and the grinding, amounts to $100,000.

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* Piles of these bivalve shells are sometimes seen on the edges of the marl banks, and on the shores, that have been carried there by the muskrats, to devour the testaceous animals.

Notwithstanding this heavy tax upon our farmers for the importation of a mineral manure, they cheerfully pay it, because they are amply remunerated by the increased productiveness of their lands. The use of marl may prevent a large portion of this outlay; and it is sincerely hoped that our intelligent farmers will make the experiment of the marl, which is so abundant, and which has been accumulating during successive ages of time, by the growth and decay of myriads of animated beings, with a view to the final benefit of man.

The term *marl*, in its strict mineralogical sense, means an argillaceous carbonate of lime; but by general usage, marl is an earthy mineral substance, which, by being spread upon the soil, renders it more fertile. The marl which we have been describing, is a fresh-water shell-marl. The marls of New-Jersey, and the States south of it, are various in composition. Some are calcareous, and others are composed of green sandy grains, whose chemical composition is a potash-silicate of iron. The marls of these States are marine depositions, and contain an abundance of the remains of marine animals. The fresh-water shell-marl of New-York will not yield to any other in its fertilizing effects, unless to the green marls of New-Jersey and Maryland. If it be judiciously employed, it will return millions to the pockets of our farmers. The argillaceous marls will be discussed in another place.

Marsh Alluvions.

Peat. This alluvion is the result of vegetable decomposition. It varies in its aspect: the best quality is a soft, unctuous, tremulous mud, when wet; but when dry, is so compact as to receive a slight polish. When heated, it burns with flame and bituminous odor. Ligneous, fibrous, and compact peat are the principal varieties: The two former are of comparatively little value; the latter is extensively used in France and Ireland, and is considered a valuable fuel. It is used not only for domestic purposes, but also in burning lime, bricks, and pottery. In cold climates it is formed in moist ground and shallow ponds, wherever there is an accumulation of vegetable matter. Decayed trees form a light, soft, spongy mass, called *ligneous peat*. From decomposed grasses and seeds, a fibrous peat is formed, which is light and spongy several feet below the surface, but at a greater depth it may be of a good quality for fuel. Small aquatic plants, and mosses, such as the Sphagnum palustre, produce peat, which at a moderate depth is compact, without fibres, uniform in its texture, and of good quality. Many of the swamps or marshes where this combustible abounds, are overgrown with bushes and trees; but those not so overgrown are covered generally with moss and cranberry vines. The latter variety of peat bogs trembles under the foot.

Peat abounds in many parts of the district; in fact there are few marshes that do not contain it. The best peat lies at the depth of three or four feet below the surface; as that above often contains vegetable fibres of partially decayed plants, and is inferior in quality to the compact, black or brown tremulous mud that lies below. Ligneous peat, or that derived from decayed wood, is as common as the other, but is inferior in quality. It is found in almost all low grounds, and frequently contains the trunks and branches of cedar and other kinds of wood of great durability, which have undergone little change.

It is a circumstance of no small practical importance, and one that serves to show the adaptation of means to ends, that peat is rarely seen in warm climates, while it abounds in cold and wet regions. The reason is obvious; in warm climates the organic alluvions are too nearly decomposed to form peat, and the organic matter is removed, either by insects or by putrefaction. Peat is so common in every part of the First Geological District, that it may almost be considered superfluous to mention localities. There are undoubtedly many deposits of this useful material that were not examined, but the following table indicates many of the more important deposits of peat and marl. These materials are of great prospective value to the community, to afford nutritive and stimulant manures for the soil, and fuel and lime in those parts of the State where coal and wood are dear, and where limestone does not occur.

The collection of vast stores of these and other materials in such situations as will be most useful, and their accumulation in times past when the surface of the earth was occupied by other animals than man, shows an adaptation of means to ends by the Great Creator of the Universe, for the supply of man whenever he may need them for use.

TABLE OF LOCALITIES OF PEAT AND MARL.

Peat.	Lake or shell marl.	No. of acres.	County.	Locality, and miscellaneous remarks.
Peat,	Marl,	10	Washington, .	S. Argyle, between Reed's Mineral spring and Argyle.
P	M	30	do .	S. Argyle.
P	M	50	do .	S. Argyle, at south end of Summit lake.
P	M	25	do .	N. Greenwich, on A. McNeill's farm.
P	M	10	do .	N. Greenwich, on P. Reynolds' farm.
P	M	1	do .	Ditto ditto.
P	M	500	do .	Greenwich, various owners, one mile south of Lakeville.
P	..	100	do .	Between N. Argyle and Hartford.
P	..	10	do .	Greenwich, one and a half miles southwest of Lakeville.
P	..	70	do .	One mile southwest of N. Greenwich.
P	..	*10	do .	Easton, on Stephen Durham's land.
P	..	*10	do .	Easton, on Simeon Burton's land.
P	..	*30?	do .	Salem, four miles northwest of the village.
P	..	*60	do .	Salem, three miles north of the village.
P	..	20	do .	W. Hebron, two miles southeast of the village.
P	..	1,000	do .	Kingsbury, on summit of Champlain canal.
P	..	50	do .	Fort Ann, between two lakes south of Mt. Hope.
P	..	30	do .	Fort Ann, two miles northeast of Mt. Hope furnace.
P	..	*100	do .	Dresden, in several bodies.
P	..	*30	do .	Putnam, four miles northwest of the ferry.
P	..	53	Rensselaer,...	Greenbush, on Boston turnpike and near railroad.
	M	*	do ...	Sandlake, northwest corner, on G. Sharp's land. } Eaton's Geologi-
	M	*	do ...	Sandlake, half mile south of above, in a pond. } cal Report.
P	M	8	Albany, ...	Coeymans, three miles from N. Baltimore, on Mr. Clark's land.
		25	Richmond, ...	Several localities, small bodies, and not deep.
P	..	Several.	.....	Near Newtown, Long Island, (long used.)
		20 to 30	.....	Between Williamstown and Jamaica, called Cedar swamp.
		2 or 3	....	One mile north of Jamaica.
P	M	60	Columbia,....	Pond four miles north of Kinderhook.
P	..	6	do	Mr. Van Alen's farm, three miles north of Kinderhook.
P	..	9	do	North part of Stuyvesant, one mile from river.
P	..	Sev'r'l localities, small.	do	Ditto.
P	..	.....	do	Round pond, in north part of Kinderhook.
P	..	30 marsh & shoals.	do	Kinderhook lake.
P	..	2 or 3	do	Between Kinderhook lake and N. Chatham.
P	..	10	do	One mile north of Kinderhook, west of post road.
P	..	30	do	One mile southwest of Kinderhook, Lucas Hoe's land.
P	..	Several localities.	do	Between Kinderhook and Stuyvesant, township line.
P	..	5	do	Two miles northeast of Valatie.
P	..	Several localities.	do	New-Lebanon, Gillet's, Tilden's, etc.
		15	do	New-Lebanon, Mr. Carpenter's land.
P	..	30	do	New-Lebanon, Mr. Wait's land, south of Fitch & Kirby's store.
P	..	.....	do	Adgate's pond, west side of Canaan mountain.
P	..	.....	do	Milan, one-fourth of a mile east of La Fayette Corners.
P	..	6	do	One and a half miles east of Upper Redhook.
P	..	*	do	Southwest of Becraft's mountain, near Hudson.
P	..	*	do	Ghent, Tobias Legget's farm.
P	..	20	do	Kinderhook, on Samuel Crocker's farm.
P	M	*	do	One or two miles west of Malden.
P	..	Several localities.	do	Ghent, in south part of the town.

* Localities thus marked not examined personally, but do not doubt their correctness.

(TABLE — CONTINUED.)

Peat.	Lake or shell marl.	No. of acres.	County.	Locality, and miscellaneous remarks.
P	..	15	Columbia,....	One and a half miles north of Hillsdale.
P	..	6	Dutchess, ...	Between Hopewell and Stormville, in Fishkill.
P	..	40	do	Between Hopewell and Fishkill, several localities.
P	..	5	do	Between Stormville and Beekman.
P	..	300	do	Pawling, extends from north end of Long pond, down its outlet.
P	..	150	do	Amenia, on Lawrence Smith's and other farms.
P	..	.....	do	Four miles northeast of Dover, east of the creek.
P	..	.....	do	One mile south of the above.
P	..	.....	do	Ditto ditto.
P	..	.....	do	Two miles south of Dover.
P	..	60	do	Northeast part of Dover township, ancient lake filled up.
		40	do	South of the above, ancient lake filled up.
P	..	.....	do	Ameniaville, Dr. Stanton's farm.
P	M	.....	do	Two miles northeast of Ameniaville, on Dea. Sanford's farm.
P	..	.....	do	Pine-Plains, one mile south.
P	..	.....	do	Pine-Plains, Cranberry marsh, near Stessing pond.
P	M	.....	do	Pine-Plains, Cedar swamp, near Stessing pond.
P	M	300	do	Pine-Plains, valley of Stessing pond.
P	M	200	do	Stanford, valley of Stessing pond.
P	..	25	do	Poughkeepsie, three miles east of town.
P	..	2	do	Two miles from Union corners.
P	..	65	do	* Clinton, four miles east of Union corners, on land of Messrs. Underwood and Dennison.
P	..	90	do	Two miles south of Union corners.
P	..	5	do	Pawling, two miles north of Hurd's corners.
P	..	60	do	Stanford, in southeast part.
P	..	.....	do	Shaw pond, between Stanford and Washington.
P	..	.....	do	Mud pond, between Stanford and Washington.
P	..	.....	do	Round pond, Washington.
P	..	50	Sullivan,.....	Summit of canal between Wurtsboro' and Red bridge.
P	..	1,000	do	Along canal between Wurtsboro' and Cuddebackville.
P	..	*	do	A few miles west of Ellenville.
P	..	500	do	South of Monticello, in valley of Three brooks.
P	..	50	do	One mile southwest of Monticello.
P	..	8	do	Half a mile southwest of Monticello.
P	..	10	do	Half a mile west of Monticello.
P	..	60	do	Several marshes between Monticello and Bridgeville.
P	..	40	Ulster,.....	North end of Passant Binnewater, between Dashville and Esopus.
P	..	10	do	One mile north of the above, on the north branch of the south fork of Black creek.
P	..	60	do	Several bogs on Black creek, near Poughkeepsie and Paltz road.
P	..	20	do	Marlborough, on south road from Marlborough to Pleasant Valley.
P	..	10	Delaware,....	Roxbury, in valley of east branch of the Delaware.
P	..	.....	Columbia,....	Copake.
P	..	40	.....	Taghkanic, one and a half or two miles west of Crysler's pond.
P	..	* 300 or 400	.....	Drowned lands in Ancram.
P	..	30	Putnam, ...	Near east side of Mahopack pond.
P	..	500	do	Near Patterson.
P	..	8	do	Two miles east-northeast of West Point, in Phillipstown.
P	..	20	do	Eight miles from Coldspring, on road to Putnam court-house.

* Rev. Mr. Shafter, of New-York, observed peat and marl in Rhinebeck, Northeast and Clinton, in 1817. He gave a section of one of the marshes, which is as follows :

1. Sod and vegetable mould.
2. A stratum of turf on peat,..... 3 to 4 feet.
3. A stratum of peat and marl mingled,..... 2 feet.
4. A stratum of pure marl,..... 2 to 3 feet.

" Below these was an appearance of sand and blue clay. The peat by drying acquires a high degree of solidity."† It is easily kindled, burns with a bright flame, yields a bluish smoke, and produces an odor similar to that which attends the combustion of gramineous substances.

† American Journal of Science, Vol. 1, p. 139.

(TABLE — CONCLUDED.)

Peat.	Lake or shell marl.	No. of acres.	County.	Locality, and miscellaneous remarks.
P	..	20	Putnam, ...	On the road from Putnam court-house to Patterson.
P	..	6	do	Four miles southeast of Pecksville.
P	..	10	Westchester, .	One mile south of Scrub-oak plains.
P	..	60	.....	One quarter of a mile west of Bedford.
P	..	50	.....	Two and a half miles south of Crumponds village, on A. Underhill's farm.
P	..	*150	.....	East of Croton, and four miles southeast of Somerstown plains.
P P	..	20	.....	Phillipstown, east of Stewart's iron mine.
P P	..	10	.....	Phillipstown, half a mile south of above.
P	..	50	.....	Phillipstown, near Davenport's corners, five miles northeast of Cold Springs.
P	..	20	.....	Phillipstown, in south-southeast part, near Saxon Smith's.
P P	M	17,000	Orange, ...	Drowned lands on Walkill, ancient lake filled up.
P P	..	500	do	Graycount meadows, in Goshen and Blooming Grove.
P P	..	.....	do	Abounds in Warwick.
P P	..	.....	do	Ditto Minisink.
P P	..	.....	do	Ditto Goshen.
P P	..	.....	do	Ditto Monroe.
P P	..	.....	do	Ditto Cornwall.
P P	..	.....	do	Ditto Blooming-Grove.
P P	..	.....	do	Ditto New-Windsor.
P P	..	.....	do	Ditto Newburgh.
P P	..	.....	do	Ditto Montgomery.
P P	..	.....	do	Ditto Hamptonburgh.
P P	..	.....	do	Ditto Crawford.
P P	..	.....	do	Ditto Walkill.
P P	..	.....	do	Ditto Mt. Hope.
P P	..	10	do	Near Townsend's ore bed, Canterbury.
P P	..	20	do	Several localities near Fort Montgomery.
P P	..	10	do	Several localities near Fort Putnam.
P	..	10	do	Five miles southwest of West-Point, and half a mile west of Round pond.
P	..	5	do	Near Patterson iron mine.
P	..	30	do	Near Crossway iron mine.
P	..	50	do	East of Sterling iron mine.
P	..	40	Rockland,....	One mile south of Long Clove, on J. Van Houghler's land.
P	..	50	do	Two miles west of Nyac, in the valley of the Hackensack.
P	..	5	do	North end of Rockland lake.
P	..	40	do	One mile southwest of Sneidiker's landing.
P	..	50	do	Between the lower village of Clarkstown and the Hackensack river.
P	..	40	do	On turnpike on the mountain, between Haverstraw and Munroe works.
P	..	50	do	Ditto ditto ditto.
P	..	10	do	In valley of Stony brook, in valley of mountains.
P	..	10	.....	North end of Long pond.
..	M	7	Columbia,....	Crysler's pond, Copake.
..	M	10	do	Rhoda pond, Copake.
..	M	8	do	Woodward's pond, Copake.
			do	Hillsdale, two localities: 1st, in pond on Mrs. Burton's farm 2d, on lands of Mr. Mitchell and Judge Loop.
..	M	20	Dutchess.	Buttermilk pond, Pine-Plains.
P	M	500	do	Stanford and Pine-Plains, south of Stessing pond.
..	..	2	do	South part of Redhook township.
..	M	50	do	Long pond, one and a half miles east of Upper Redhook.
..	M	2	do	Milan, one quarter of a mile east of La Fayette Corners.
..	M	50	do	Stanford, in Thompson's pond.
..	M	30	do	Stanford, in Upton's pond.
..	M	10	do	Marsh in Rhinebeck, on Major Pultz's farm.
..	M	2	do	Marsh in Rhinebeck.
..	M	1	do	Marsh in Rhinebeck, on Mr. Suckley's land.
..	M	130	do	Chalk pond and Round pond, in Amenia.
..	M	1	do	Two miles east of Amenia.
..	M	10	do	Clinton, several marshes, and probably in the pond.

More abundant in this county than perhaps in any other in the State. Probably from 30,000 to 40,000 acres.

Marine Alluvions.

Salt Marshes, or Marsh Alluvions.

Salt marshes are very extensive on some parts of the coast of Long Island, Staten Island, and Westchester county. These alluvions result from a combination of several causes. The first step in their formation, is the deposit of a sand or shingle beach, by marine currents sweeping along detrital matter, and depositing it in the eddy currents, in front of shallow bays and in the reënterings of the coast, so as to shelter these spaces from the action of the surf, if they were before exposed to it. They are also made shallower by the sand and silt carried in by the tide, the deposits from the surface waters of the adjacent country, and by sand drifted from the beach. Not only marine animals and plants, by their growth and decay, add new matter to the gradually shoaling pond or bay, but the accumulation of drifted sea-weed, trees, etc. serve to increase the alluvion at every successive storm. These various causes combined, gradually shoal the water with alluvial depositions, until marsh grass finally takes root upon the surface. In the formation of these marine alluvions, vegetable remains far exceed the other materials in volume, so that an imperfect marine peat results. The marine peat observed in most localities, was of inferior quality: it was light and spongy, containing undecomposed vegetable matter.

The relative proportion of salt marsh on the coasts of Queens, Kings and Richmond counties, is much greater than on those of Suffolk county. These marshes are now forming, and have been for an unknown period of time. In some places they are washing away, in others they steadily increase in extent. I have been credibly informed that grass now grows on a marsh near Rockaway, where vessels have floated within the memory of my informant. On Coney island, also, Mr. John Wyckoff informed me, that many places which were ponds and pools within his recollection, now produce good crops of grass. A very aged man also recollects having seen the surf roll in at the foot of the upland north of the marsh towards the east end of Coney island. A broad marsh now intervenes between the upland and the beach.

A combination of several of the causes producing salt marshes, is particularly favorable to their rapid increase; such, for instance, as the alluvion washed down by streams; the fine materials swept from the headlands, and carried into the bays and reënterings of the coast by the flood tide, where they are deposited; the fine earthy matters formed by the surf grinding the pebbles on the coast, being transported by the tidal currents into the bays and marshes, and deposited there; the growth and decay of multitudes of marine animals; the accumulations of marine plants, drifted sea weeds, and other refuse of the ocean, and clouds of drifting sand; all of which concur to shoal the water more or less rapidly in situations where it is protected seaward by beaches and islands.

These marshes are valuable on account of the salt grass, of which they yield an abundant crop. Many of these marshes are so located that, with a trifling expense, the tide, surface

and spring waters of the adjacent country might be excluded, and thus they might be rendered capable of tillage, like those of Holland. The soil is very rich; in fact, it is composed mostly of organic matter, mixed with some lime and saline substances, and can be made to produce valuable crops. It is scarcely possible that another generation will pass away, before the suggested improvement will be made on some of these rich alluvions. The value of land on Long and Staten islands will not always allow these marshes to be as unproductive as they are at present.* Many of them might also be employed to advantage in the manufacture of salt from sea water, both by solar evaporation in summer, and by allowing it to freeze during winter. It is well known that it is the fresh water only which freezes, thus rendering the brine much stronger, and that it can be so concentrated until the salt separates in a crystallized state.

The disadvantage in winter would be, that only one crop of crystals could be obtained; but an area of sixty acres, divided into compartments of ten acres each, communicating with each other, so that six feet of water could be let into the first, would give for a single crop from 25,000 to 30,000 bushels of salt.

Localities. The principal marshes of Long Island are, Nepeague marsh; one between Sagg ponds and Mecock bay, east part of Shinnecock bay; between Moriches and Great West bay; between Ocombamack neck and Fireplace; Ocombamack neck and Patchogue; Patchogue and Nicholas neck; and the very extensive one from Nicholas neck to Rockaway; and those about Jamaica bay and Coney island. There are also many on the north shore of Long Island, the principal of which are at Acabonnick, Oyster ponds, Riverhead, Wading river, Smithtown harbor, Crab meadow, Lloyd's neck, Oysterbay harbor, between Peacock and Oak neck, Musquito cove, north part of Cow neck, Little-neck bay, Flushing, Williamstown, Brooklyn, and Cowannus.

The salt marshes of Staten Island, though not numerous, are extensive. The principal are the Greatkill meadows, Freshkill marshes, and those along the west coast of the island.

The salt marshes of Suffolk county are estimated to cover an area of fifty-five square miles; of Queens county, forty; Kings, twelve; Richmond, nine; Westchester, nine; and New-York, three; which give an aggregate of one hundred and twenty-eight square miles, or about 82,000 acres.

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* When these marshes shall be cultivated, it is anticipated that no difficulty will be encountered in procuring good fresh water, both for men and animals. The geological formations in the vicinity of Newark are similar to those of Staten and Long islands. The following section, obtained by Mr. Disbrow, in boring for water in the Newark meadows, will show the strata passed through; and from the bottom an abundant supply was obtained, which arose to within three feet of the surface.

Marsh mud and roots,	10 feet.
Quicksand,	12 "
Bluish grey clay,	36 "
Sand,	6 "
Ash-colored clay,	20 "
Stiff variegated clay,	20 "
Total,	104 feet.

(VIDE *Amer. Jour. Science*, Vol. 12, p. 139.)

The salt marshes of the island of New-York are the Stuyvesant meadows, extending from Corlaer's hook to Twentieth-street, and about half a mile wide, now mostly covered with gravel, graded, laid out in streets, and partly built over; and the marshes near Harlem and Kingsbridge. The Collect was a quagmire seventy-five feet deep in the middle, and received the drainage of the higher grounds around. The water at its bottom was as salt as that of the Hudson, and from which its salt water is supposed to have filtered through the gravel. This pond and mud-hole had an outlet leading to the East river, along where Roosevelt-street is at present, and another communicating with the Hudson across the Lispenard meadows. This latter outlet crossed Broadway at the present corner of Broadway and Canal-street. Mr. Disbrow, in boring for water at the Halls of Justice in Centre-street, passed through forty feet of made earth, and thirty of black mud, in the old Collect. Blue clay and gravel lay below, and the latter rested on the rock. "The Lispenard meadows extended from Broadway to the Hudson, and from the vicinity of St. John's church to Spring-street, including the range of Thompson, Laurens and Wooster-streets." (*Prof. Gales' Report.*)

The meadows on the Hudson river, classed under the fluviatile alluvions, might also be classed as salt marshes as far up as Hudson. The salt water reaches as far as that city during spring tides, and when the river is low in the summer. The principal of these are the meadows south of Nyack; those at the mouth of the Croton river; near Haverstraw; near Peekskill; between Caldwell's landing and Fort Montgomery; and those of Consook island, and of Constitution island.

The coarse marine peat of the salt marshes may also be made available for making carbonate of soda, or a substance analogous to barilla or kelp, since it is saturated continually with salt water. If dug, dried and burned, the ashes would afford this material.

Encroachments of the Sea.

The coast of Long Island on the south side, from Montauk point to Nepeague beach, a distance of about ten miles, is constantly washing away by the action of the heavy surf against the base of the cliffs, protected only by narrow shingle beaches of a few yards or rods in width. The pebbles and boulders of these beaches serve as a partial protection to the cliffs during ordinary tides in calm weather; but even then, by the bouldering action of the surf as it tumbles upon the shore, they are continually grinding into sand and finer materials, which are swept far away by the tidal currents. During storms and high tides, the surf breaks directly against the base of the cliffs; and as they are formed only of loose materials, as sand and clay with a substratum of boulders, pebbles, gravel and loam,* we can easily appreciate the destructive agency of the heavy waves rolling in unbroken from the broad Atlantic. The destruction of land, from this cause, is less than one would be led to suppose, but still it is considerable. The road from Nepeague beach to Montauk point, which was originally at

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* Vide Section at Montauk point.

some distance from the shore, has disappeared in several places by the falling of the cliffs. There are no data by which to estimate the inroads of the sea on this coast.

From Nepeague beach to two miles west of Southampton, the south coast of Long Island is protected by a broad and slightly inclined sand beach, which breaks the force of the surf as it rolls in from the ocean. From Southampton, westward, the coast of the island is protected by long narrow alluvial islands, from one mile to five or six distant from the main island.

Some parts of the north shore of the south branch of the island, from Montauk point towards Sag harbor, are washing away, but not so rapidly as on the south side of this branch of the island.

The eastern parts of Gardiner's and Plum islands, which are composed of loose materials, are washing away in consequence of the very strong tidal currents and the heavy sea rolling in upon their shores from the open ocean. The action upon these coasts is so rapid as to attract the attention of the inhabitants; and calculations even have been made, as to the time that will probably elapse before they will have disappeared. Rocks (boulders) that have formed a part of Plum island, may now be observed at low water, a mile or more from the present shore. Little Gull island, on which a light-house is located, was disappearing so rapidly a few years ago, that it became necessary to protect it from the farther inroads of the ocean by encircling it with a strong sea wall. Oyster-pond point is wearing away rapidly by the combined action of the waves during the heavy northeast storms, and the strong tidal current that flows with great velocity through Plum gut. A small redoubt about a quarter of a mile west of the point, is nearly washed away; and Mr. Latham, the owner of the farm, says, that several rods in width have disappeared since his remembrance. During the heavy storm of October 12, 1836, the sea made a clear breach over about a quarter of a mile of the eastern part of the point, washed away all the light and fine materials, and cut a shallow channel through which the tide has since flowed. The effects of this storm were very marked on the shores of Long Island, and particularly on the north coast. The cliffs were undermined, and crumbled or slid down, exposing the geological structure, and presenting beautiful coast sections of the strata.

The importance of a thorough understanding of the causes now in action that serve to shoal water, and wash away the land or shift the position of the deposits, by the engineer engaged in the construction of public works, such as breakwaters, piers, fortifications, etc., and even the location of towns and cities, is obvious to all, and yet they are but little studied.

Coney island, which is mostly alluvial, is rapidly washing away on its south side, where it is exposed to the full force of the ocean swell. A new direction given to the tidal currents by some recently formed bar, is probably the cause. Mr. John Wyckoff, who lives near the Ocean House, remarked that the sandy part of the island was a mile broad, not many years ago, though now it is not more than half that breadth. He informed me that every storm made a sensible difference, and that some years ago the sand-hills south of the Ocean House were covered with small pines and bushes; and that in a single night, during a violent storm, the trees and bushes, and much of the earth, were washed away.

The high grounds near the two light-houses on Staten Island are wearing away by the action of the waves, and the materials are mostly deposited on the adjacent beaches, which extend for a considerable distance west of Fort Tompkins, and east and west of the southwest light-house. The high bank near Brown's point, on Staten Island, is also washing away. Here a bank of shells about two feet thick is exposed, within eight or ten inches of the natural surface of the ground. They appear to be recent shells, deposited there, not by nature, but by the hands of the aborigines of the country. The evidences are, they are all edible species, the opposite valves of bivalve shells are scarcely ever found together, and the localities of these shell banks are such as would naturally be selected for camping grounds and villages by such people as derived a large share of their food from the adjoining waters.

Hog island, as it has been called, or Middle island, the name given by the coast surveyors, is gradually wearing away in many places by the action of the waves during storms and high tides; but the north-northeast and northwest parts are exposed to the waves of Long Island sound, and are wearing away more rapidly. The materials of which this peninsula, as well as nearly the whole of Long Island, is composed, is a series of beds of sand, gravel, loam and clay. Boulders and erratic blocks occur in one of the beds in great numbers; and as the surf undermines the cliffs, they tumble down, and all the finer materials are swept away by the tidal currents, and the oblique action of the surf on the shore. The headlands, generally, of the north shore of Queens county, are washing away. The blocks of rock which were once imbedded in the loose soil of the island are seen on the beach, extending out far beyond low water mark.

At Oak neck, Fox island and Martinecock, as well as at Middle island, the boulders extend far out at low water, and demonstrate the encroachment of the sea on the land. Middle island and Oak neck are parts of a peninsula which lies between Oyster bay and Long Island sound. They were once islands, but have been connected with each other and with Long Island, by beaches formed of detrital matter, swept from the headlands of Middle island and of Oak neck. Extensive salt marshes are forming under the protection of these beaches, and are materially increased by the sand drifted from them. These beaches are observed to vary in form and magnitude, being sometimes increased or diminished in particular parts by the effects of a single storm. Fox island, so called, was once an island, but it is now connected with Oak neck and Long Island on the east by a long beach. A long sand spit of a mile and a half in length, extends to near Peacock's, where it is cut off by an inlet, which communicates with the extensive marsh between Fox island and Long Island. This beach and spit are derived from the materials washed from Fox island and Oak neck.

Peacock's point is also washing away. Stumps and logs of wood are seen below low water mark. Martinecock point, a mile or more west of Peacock's, must have washed away rapidly. A long point of boulders and blocks stretches far out into the sound at ebb tide. This was once an island, which is also connected with Peacock's by a long sand beach. Another ancient island, now connected with Long Island on the southwest by a beach, is very near Martinecock on the west. These two islands and beaches enclose a large pond, the inlet

of which is through a mill sluice between them. Mr. Jacob Latting, who is an old and respectable inhabitant, and has been a resident in the vicinity more than half a century, informed me that these have been worn away many rods within his recollection. Mr. Latting pointed out to me the position of the beach between Peacock's and Fox island, during the revolution. The beach then dammed up the outlet of a marsh, through which a small stream flowed; and a trunk was put in the beach in 1778, to allow the water to drain through, in order to prevent flooding the meadows. I saw the trunk in its original position. The beach has since been extended about two hundred yards in breadth in front of where it was at that time. He observed that these beaches are subject to considerable variations by storms, the materials being tumbled along either eastward or westward, according to the direction of the wind.

Sands' point, on which a light-house has been long built, was washing away so rapidly some years since, that it became necessary to protect it by building a strong sea wall along the shore. A reef of rocks (the remains of ancient lands) extends out some distance from the shore. The wall has afforded a protection against the encroachment of the sea, and about an acre of land has been added to that belonging to the United States, in consequence of the alluvial action of the surf depositing the sand and shingle in the eddy on the south side of the point. Mr. Mason, the keeper of the light-house, communicated these facts, and many others of much interest. The broad and extensive sand-beach south of Sands' point, a mile or more in length, was, since his remembrance, a salt marsh covered with grass. Mr. Mason is nearly eighty years of age. The materials swept from Sands' point and deposited on the edge of the marsh, have been drifted and washed over its surface.

At and near Kidd's rock, three-quarters of a mile eastward of Sands' point, the wasting of the cliffs from the effects of the waves is very evident. The cliffs present mural escarpments towards the sound, but the hills slope down gradually on the other side towards the salt marsh. This elevated land was formerly an island, but alluvial causes have formed a salt marsh where the water was sheltered from the sea. The wasting of the cliffs has caused the formation of long beaches, one connecting Kidd's point with Sands' point, and the other connecting with the high grounds southeast of the marsh on the west side of Hempstead harbor. A small inlet through the north end of this beach allows the tide to communicate with the marsh. Boulders and blocks are seen imbedded in the strata forming the mural escarpments, and the shore below is also strewed with them. They also extend some distance from the coast, indicating that a considerable breadth of land has been washed away. The boulders protect the shore for a time, but the smaller ones and the shingle are gradually ground up by the action of the surf, and washed away; and during storms and high tides, fresh inroads are made. The beach between Kidd's point and Sands' point covers a part of the marsh, the ooze and marine peat of which may be seen at the foot of the beach at ebb tide. This indicates that high land or else a beach was once farther seaward, to afford protection for the formation of that part of the marsh.* Only a few acres of high land remain at Kidd's point, and if it should

* Vide plate 1, figures 1 and 2.

continue to be washed away as heretofore, (and much expense would be necessary to prevent it,) a century or two would be sufficient to effect its entire removal.

Kidd's rock, as it is called, is a remarkable erratic block which was imbedded in the loam of the tertiary formation. It has been undermined by the action of the sea, and has slid down to the shore, and cracked in many large fragments. Viewing it from a little distance, one does not realize its magnitude; but by climbing over and wandering among its fragments at low water, it seems to grow upon the imagination. Its fragments probably weigh at least two thousand tons, and several sloop loads of it have been shipped to New-York for building stone. It is hornblendic gneiss, and some of its masses abound in epidote. It is a durable stone, and will stand any exposure unchanged.

Several companies of diggers for Kidd's money have expended much time and labor at this place. Mr. Mason relates many amusing anecdotes relative to their mode of operating, and the ceremonies practised, some of which are sacrilegious. The superstitions connected with these gold hunters are a rarity of this enlightened age. I presume I speak within bounds when I remark, that in examining the geology of Long Island, I have seen many hundreds of excavations on the east side of the boulders and erratic blocks, where the gold hunters have dug for this pirate's money.

The rock called Kidd's rock, at Kidd's point, three quarters of a mile eastward of Sands' point, is not the same that was known by that name a century ago. Mr. Mason informed me that Kidd's rock was formerly the extremity of the point, but was long ago undermined by the waves. He remembers having seen it as an isolated rock, some distance from the shore, but it has since disappeared, and the rock on the present point is called by that name. Had the money diggers been aware of this fact, it might have spared them the labor of searching here. In some parts of Long Island, almost every boulder and block has had an excavation made by its side.

Barker's and Hewlet's points have also been worn away by the action of the sea; but the sound is here so narrow, that the destructive agency of the waves is not so great as at the localities before mentioned.

Many other localities, where the same effects are in progress, on the west and southwest parts of Long Island, and on the north coast from Oyster-pond point to Mount Misery, might be mentioned; but they are less marked in their effects, because they are not so much exposed to the fury of the surf from broad sheets of water.

Marine Alluvial Detritus.

Beaches, Shoals, Spits, &c.*

The destroying action of the sea upon the headlands and cliffs where currents and a heavy surf beat against the coast, has been considered. Another effect of the sea, and as important to the community as that just discussed, is the formation of marine alluvion. It results from the deposition of the materials transported coastwise by tidal and marine currents, and by the action of the waves in the direction of the prevailing winds and storms. The winds which produce the greatest transport of alluvial matter on the coast of Long Island, (with the exception of particular parts, where there are local exceptions in consequence of the form of the shore, or direction of currents,) are from the northeast, during the heavy northeast storms. These storms bring in a heavy swell from the ocean, which, rolling obliquely along the shore, aided by the powerful tidal current, sweeps the alluvia along in a westerly direction. The northwest winds are nearly as powerful as the northeast, and blow for a much longer period in the year, but do not bring in an ocean swell; and the waves which they raise, fall upon the shore in a line nearly perpendicular to the trend of the coast; so that their effect is to grind the pebbles and gravel to sand, by the action of the surf, rather than to transport them coastwise. In this way, outlets of small bays are frequently more or less obstructed by bars, shoals and spits, formed by the tidal currents sweeping past their mouths, and depositing the materials in the eddy formed by the meeting of the currents. If the strongest currents and prevailing winds be coincident in direction, the outlet of the harbor is on the leeward side.

When rivers and small streams do not project deltas into the sea, the surf frequently throws up a bank of shingle or sand, so as to block up their mouths; and then, a fresh water pond or lake is the result. This effect, however, is much modified by the size of the materials, forming the beach across their outlet. If the materials be coarse gravel and pebbles, or shingle, the water filters through at ebb tide, so as to retain it near the tide level; but if they be fine sand, the water accumulates until it overflows the obstacle, or has a sufficient head to excavate a channel through the barrier, and escape.

Almost every bay, inlet and marsh, on the north coast of Long Island, and also on the south coast, where they are not protected from the sea by the long sandy islands which have been mentioned in the preceding article, have their outlets blocked up entirely by the materials deposited, or so nearly as to leave only narrow entrances. Strong currents set along the shore; and these, aided by the oblique action of the surf, roll the pebbles and sand up the beach, which, on the retiring of the waves, are swept again into the surf, having described a semicircular line, and perhaps progressed several feet by the action of a single wave. This

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* *Spit*, in the usual acceptation of the term, when applied to alluvial deposits, means a long point or tongue of land composed of sand or shingle, extending out from the shore, and formed of materials swept along by the tide or waves.

mode of transport is seen almost every where on these coasts. The cliffs are undermined, and the coarser parts of their wrecks are thus tumbled along from place to place by each succeeding storm. The particular local effects of such causes can only be fully understood by visiting the localities, or having accurate detailed topographical maps, like those now in progress under the supervision of the Superintendent of the National Coast Survey. The map of Long Island accompanying this report, and for which that of J. Calvin Smith is the basis, and which is far more accurate than any heretofore published, will enable the reader and student to understand most of the alluvial changes of Long, Staten and Gardiner's islands.

The transporting action, above alluded to, has been the most effective agent in the formation of the marine alluvions of Long Island. This island has been composed of one principal and several small detached islands, which are now connected with each other and with the main island. The east end of the island, from Montauk point to Nepeague beach, seems to have been at some former time two separate islands, which have since been connected with each other, and with the main island, by the westward currents sweeping along detrital matter, derived from the continual destruction of cliffs of loose materials. Nepeague beach is five miles long, a great part of which is loose drifting sand, enclosing marshes and salt ponds. This beach is so low in some places that the tides frequently overflow it. The skeleton of a whale is said to be now imbedded in these sands. At Fort Pond bay, a few miles east of Nepeague beach, a narrow strip of shingle, frequently overflowed by the tides, separates the Atlantic from this bay, which is separated from Long Island sound by a beach, sometimes open, but often blocked up with sand. Great Hog neck, and Little Hog neck, near Sagg harbor, were once islands which have been united by a sand and shingle beach, and the latter with the main island. Farrington neck, a few miles west of these, was an island which is now united with the main island by a low beach. That part of the township of Southold, which is situated on the main island, was originally three islands, now connected with each other and with the main island, by beaches and marshes of alluvial formation.*

Those long points of alluvion called *sand-spits*, projecting from the land, in the line of the eddy currents, and formed by them, are very common; and they are, in fact, the unfinished beaches which will eventually obstruct the outlet of harbors and bays, and connect islands with each other. An interesting alluvial formation is now in progress on the north and north-west sides of Loyd's neck, in Huntington, and formed entirely by the deposit of the coarse detrital matter, swept along by the current from the destruction of the high cliffs in the vicinity. This deposit is about one quarter of a mile broad, partly marsh and salt pond, protected

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* The effects of alluvial action can be distinctly seen on the map of Oyster-pond point. This map shows where two of the islands which were once separated from the east end of the north branch of Long Island, have been connected by the beach E, and the sand-spit C, enclosing a large pond F, with an outlet only wide enough for a mill-sluice. A tide mill is constructed at this outlet. Mr. W. H. Sidell, a highly promising and accomplished civil engineer, has made a minute topographical map of the country from Riverhead to Oyster-pond point, in the discharge of his duties as engineer of the Long Island railroad; and I am indebted to his kindness for being able to illustrate graphically the transporting power of the waves and of tidal currents, and the effects produced by the deposit of sand and shingle forming on these spits and beaches. (Vide Plate 32.)

by a high bank of shingle, piled up and continued westward, so that the present outlet of the pond is half a mile further west than it was a few years ago; the shingle having been continually swept westward, while the flux and reflux of the tide through the narrow channel keeps its outlet open.

The ponds and small bays on the south side of Long Island, in the townships of Southampton and Easthampton, frequently have their outlets closed by beaches, formed by the detrital matter swept coastwise by the tidal currents and the waves. The long sandy islands on the south coast of Long Island, which protect it from the heavy waves of the Atlantic, are doubtless formed by the same cause. Long beach is a sand-spit extending from Ben's point, near Oyster-pond point, westward, four and one-fourth miles, and has been formed by the detritus being swept coastwise and deposited in the eddy currents. This beach gives safety to Oyster-pond harbor, by serving as a natural breakwater. (Vide Map of Oyster-pond Point, Pl. 32.) Two sand-spits were observed in Coldspring harbor, resulting from causes similar to those above detailed.

The headlands and cliffs on the north coast of Suffolk county are continually wearing away; and the materials of which they are composed, consisting principally of clay, sand, gravel and pebbles, are transported by tidal currents, and deposited in other places.

Huntington harbor is of alluvial origin.* This harbor is formed by two necks of land; Loyd's neck on the west and northwest, and Eaton's neck on the east and northeast. Loyd's neck, which was originally an island, has been connected with the main island by a low sand-beach, now overflowed at high water; Eaton's neck was formerly a cluster of four islands, which have in the same way been connected with each other, and with the main island. A sand-spit one mile and a quarter in length, and from ten to twenty rods in width, extends out into the harbor from the southwest part of Eaton's neck, and adds much to its safety; as also a similar one from the southeast part of Loyd's neck. The materials composing the sand-beaches and spits which I have mentioned, are precisely like those now thrown up by the action of the surf; they consist of pebbles, gravel and fine siliceous sand, interspersed with water-worn shells belonging to genera and species now living on the coast; and they are destitute of boulders, which distinguishes them from most of those low places formed by the removal of the surrounding materials.

The beach connecting Eaton's neck with the main island, is three and a half miles in length, and ten to thirty rods in width. Mr. Gardner, who keeps the light on Eaton's neck, informed me, that some years since, a vessel, during a violent storm, having been driven upon this beach, and an excavation made to get her off, marsh mud was found beneath the sand near tide-water level, precisely like that in a small marsh on the opposite side of the beach, clearly indicating the manner of formation at that place. On the northwest part of Eaton's neck, a sand-beach one-half or three-fourths of a mile in length, has been thrown up in front of a marsh containing several acres. It has formed rapidly since the remem-

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* Huntington harbor embraces within it three smaller ones, viz. Loyd's harbor, Cow harbor, and one near the village in Huntington.

brance of Mr. Gardner, who says he has seen sloops loaded with wood, float in places now some feet above tide-water level. The long beach connecting Eaton's neck with the main island, is continued three-fourths of a mile eastward; and a part of the way it is formed in front of cliffs, which it protects from the farther encroachment of the sea; and the remaining distance, before a small pond skirted with marsh, which formerly communicated with the sea by means of a creek, but now is obstructed by alluvial sand.

A sand-beach one-fourth of a mile in length, has been formed between Long Island sound and Crab meadows, through which a creek, entering obliquely from the northwest, passes in a serpentine direction through the marsh. By the action of violent winds, the finer particles of sand are formed into hillocks which are slowly drifting inland.*

A similar sand-beach has been formed at Fresh-pond creek. The outlet of the small pond is often obstructed by alluvial sand, so as to obstruct the ingress of salt water. This obstruction has sometimes been removed by digging, and at others the water has accumulated in the pond, so as to burst through its barrier, and excavate a deep channel.

A sand-beach half a mile long, has been formed at Sunken meadows. It is said that the outlet through this beach has moved thirty rods eastward in a few years.

A shingle beach about a mile in length, has been formed on the north part of Crane neck, between Flax-pond and the sound. The tidal flow on this shore is so strong as to have drifted away the finer materials to the southwest part of the neck, where they have formed shoals, and a long sand-beach† between a marsh and the sea; while the coarse materials have been left nearer their source, to form the shingle beach.

Sand-spits have been formed nearly across the mouths of Drowned meadow, Stony brook, Setauket, Smithtown and Oldman's harbors. They serve as natural breakwaters to protect the harbors; but the bars at the entrances are so shallow, that vessels of small draught only can enter them.

Sand-beaches have formed across in front of the marshes on the southeast coast of Staten Island, derived from the degradation of the high banks farther east. Another small one connects Throg's neck in Westchester county, which was once an island, with the main land.

The reader will perceive, from the preceding details, that the beaches, spits, etc. are important, as tending to protect harbors, and to conduce to the formation of marshes that become in course of time lands capable of tillage; but to the man who investigates the wonderful works of our Creator, these and other facts connected with alluvial causes throw much light upon the causes that have been in operation during the deposition of many of the more ancient rocks.

Beaches, Spits, Bars, &c. of Queens, Kings, and Richmond counties.

The beaches at Middle island, Oak neck, Fox island, Peacock's, Martinecock and Sands' points, which are formed by the accumulation of the sand and shingle swept from the adjoining

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* Prof. Briggs's report to W. W. Mather.

† Sand from this beach is used for sawing marble.

headlands by marine currents, and the oblique action of the surf, have already been mentioned. Other beaches, but not so extensive, occur on the north coast of Queens county.

Sand-spits are unfinished beaches, and long tongues or points of land, formed of sand and shingle, by the transporting action of currents and the waves.

In Coldspring harbor, a sand-spit extends from the west shore, obliquely, nearly across. It is formed by the northeast storms driving in a heavy swell, which washes away the high banks at the south point of land between Coldspring harbor and the entrance to Oyster bay. The materials are transported by the currents and waves, and deposited to form this spit.

A similar spit has formed nearly across Hempstead harbor, about three miles south of the mouth of the bay, and two miles north of the village of Montrose at the head of the bay. It extends from the west shore, in an easterly direction, nearly across the harbor, leaving a deep inlet of one hundred to one hundred and fifty yards wide next to the eastern shore. It is owing to the same cause as the spit at Coldspring. This spit is probably a thousand yards in length, but is not materially affected by storms. The detrital matter *now* swept coastwise, is carried *through* the inlet, and deposited in the inner harbor. Two large shoals have thus been formed, and it is said they are evidently becoming shallower every year, and at no distant time will form a considerable addition to the land. A small spit extends from the eastern shore, a short distance north of the east end of the large one. Another spit, which extends, on the west side of the bay, from the high bank on the west side of the harbor towards Kidd's point, is separated from this point only by an inlet of thirty or forty yards, through which the tide flows into the marsh behind Kidd's island. It is formed from the detrital matter, both of this bank and of Kidd's point.

A spit of some hundred yards in length extends from the north, partly across the mouth of Plandome bay. It is derived from the detritus of some high banks in the bay, and Barker's point on the north.

There are beaches and spits on the south side of Staten Island, but of no great extent or importance. The beach extending southwest from Fort Hudson, and that opposite the Great kills, are the most extensive.

The beaches and spits we have been considering are trifling in extent and importance, when compared with the Great South beach of Long Island. This is a line of alluvial sand and shingle, extending from Nepeague in Easthampton, to the mouth of New-York bay, a distance of one hundred and four miles, and having a direction of about west-southwest. It is not continuous, but is divided by inlets communicating with the bays which are situated between this and Long Island, and through these inlets the tide ebbs and flows. At Quogue and several places east of this, Long Island communicates with the beach, either by marshes or by the upland; but westward for about seventy miles, a continuous line of bays, from half a mile to six miles broad, extends uninterruptedly, and separates the beach entirely from Long Island. This great beach is a line of spits and islands. One of the islands is about twenty-five miles long, with a breadth of a few hundred yards. They are all narrow and long; and when above the reach of the surf, they are covered by a labyrinth of hillocks of drifted sand, imitating almost all the variety of form which snow-drifts present after a storm.

Rockaway neck is the only locality west of Southampton, where the upland of Long Island approaches near the alluvial beach. The land through this distance is increasing in area by constant depositions. The beach at Far Rockaway, and for many miles east and west, is undergoing constant local changes. The surf often washes away several rods in width, during a single storm, and perhaps the next storm adds more than had been removed by the preceding. The sea frequently makes inlets through the beach to the bays and marshes, and as frequently fills up others.

The inlet to Rockaway bay, called Hog-island inlet, is continually progressing westward by the oblique action of the surf driving the sand, gravel and shingle in that direction. The deposit of these materials on the west end of the island beach tends to obstruct the inlet to the bay; but the strong tidal current, during the flow and ebb of the tide, washes away the east end of Rockaway beach, as rapidly as the other forms: the inlet is thus kept open. Mr. Edmund Hicks, of Far Rockaway, has been long a resident here, and to him I am indebted for the fact just mentioned. He knows Hog-island inlet to have progressed more than a mile to the west within fifty years.

New inlet is the main inlet from the ocean to the great South bay. It was formed during a storm not many years ago.

Crow inlet and Jones' inlet are undergoing changes analogous to that of Hog-island inlet.

Barren and Coney islands are a part of the Great South beach of Long Island.

Coney island has already been referred to as washing away by the waves and marine currents. It is alluvial, with the exception of a very small tract of tertiary, and is separated from Long Island by a small creek which winds through the salt marsh. Mr. Wyckoff, who has lived for many years on the island, remembers when this creek was a broad inlet; but it has been gradually filled up with silt, organic alluvions, and drift sand, until it is reduced to its present size.

It has been remarked, that some of the islands and spits of the Great South beach are continually receiving accessions on the west end. Long bars form in the prolongation of the beaches, so that each successively overlaps the other, the entrance being from southwest to northeast: they project in echellon, from the east-northeast to west-southwest. Many of these shoals, formed at some distance from the land, are gradually driven landwards by the surf, and make new additions to it.

During the investigation of the various alluvial causes now in action on this coast, we easily trace the origin of this great sand-beach of more than one hundred miles in length.*

The encroachments of the sea on the east end of Long Island, were discussed in my first annual report. Vast masses of the cliffs of loam, sand, gravel and loose rocks, of which Long

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* In Europe, there is no deposit of a similar character to compare with it in extent. It was hoped that the topographical maps of Long Island might be completed and published by the Government, in season to make use of them for illustrating in detail the minute geology of this interesting region. The map of Long and Staten islands appended to this report is more accurate by far than any maps of Long Island that have preceded it; but the coast survey maps would, for accuracy of topographical detail, leave nothing to be desired.

Island is composed, are undermined and washed away by every storm. The water on the ocean coast, to some distance from the shore, is almost always found to have more or less earthy matter in suspension; much of which, except during storms, is derived from the grinding up of the pebbles, gravel and sand, by the action of the surf. This earthy matter is carried off during the flood tide, and in part deposited in the marshes and bays, and the remainder is transported seaward during the ebb, and deposited in still water. After a close observation, I have estimated that at least one thousand tons of matter is thus transported daily from the north coast of Long Island; and probably that quantity on an average is daily removed from the south coast, between Montauk point and Nepeague beach. This shore of fifteen miles in length from Montauk point westward, probably averages sixty feet in height, and is rapidly washing away. One thousand tons of this earth would be equal to about one square rod of ground, with a depth of sixty feet. Allowing this estimate to be within the proper limits, more than two acres would be removed annually from this portion of the coast. It is probable that any attentive observer would not estimate the loss of land there at less than this amount. Nearly one-half the matter coming from the degradation of the land, is supposed to be swept coastwise in a westerly direction.

There are many evidences that the east end of Long Island was once much larger than at present, and it is thought probable that it may have been connected with Block island, which lies in the direction of the prolongation of Long Island. From Culloden point, a reef of loose blocks of rock projects similar to those points on Hog island, Oak neck, &c. where they are known to result from the degradation of the land. Jones' reef, northwest of Montauk point, is similar; and Shagwam reef, a little farther west, projects three miles from the shore. It is ascertained that black fish (*Labrus tautogo*, Mitchill) are rarely found except about a rocky bottom. It is also known that such a bottom of loose blocks of rock is found, wherever the natural soil of Long Island and the adjacent islands has been washed away by the sea. These facts, with the well known extensive fishing grounds for black fish around Montauk point, and particularly on the south shore, and between Montauk point and Block island, give much probability to the idea that a great extent of land there has been washed away by the sea.

Even if these evidences were deemed insufficient, the present rapid degradation of the coast in that vicinity, the constant transportation of matter westward upon the Great beach, and the extent of this beach, (more than one hundred miles long, with a breadth of one hundred to one thousand yards,) which is undoubtedly the result of this action, would to most minds be conclusive evidence of the fact.

Sand-Dunes.

Sand-dunes are low hills of loose sand, which have been piled up by the wind like drifting snow-banks; and like them, are frequently changing their magnitude and position; so that in some places productive lands are buried by the moving materials, while in others they are uncovered by their removal. An instance was mentioned to me of land in Southampton having been inundated by sand, and after a lapse of about fifty years, it was uncovered by its drifting off. On sea-coasts, and in some places in the interior of a country, the atmosphere is often

clouded during high winds with the lighter particles of drifting sand, while the heavier are rolled along on the surface. Every obstacle which creates an eddy current in the wind, as a rock, fence, bush or tree, causes a deposit of sand, which often serves as a nucleus of a hillock. The sand-banks, when first formed, present almost as much variety of outline and form as snow-drifts after a snow storm. Examples were observed on the north shore of Long Island during the heavy winds of October, 1836, where heaps of drift sand, two or three feet deep, were formed in a few hours behind boulders and blocks of rock, which created eddy currents in the wind. Sand-banks several feet deep were observed in some of the ravines next the beach, that had been formed between the time of the storm of the 12th, and the time observed on the 17th October. A small pond near Horton's point, has been converted into a meadow by the drifting sand filling it up, within the remembrance of Mr. Horton of Southold.

The sand-dunes along the shore are so prominent as to mark the line of coast in many places, when seen at the distance of several miles; presenting a very broken, undulating or serrated outline of white hillocks, from ten to forty feet high. On almost all the beaches are hillocks of drift sand, and in many places the high bluffs on the north coast are capped with them. Jacob's hill, northwest of Mattituck, was once much higher than Cooper's hill east of it; but the sand has blown off, so that it is now much lower at the former place. Some arable land has been covered over, and red cedar trees have been buried by the drift sand. The grounds occupied by the dunes are exceedingly irregular in form; in some places covered with small round-backed hills, with deep, irregular or bowl-shaped valleys, formed by the wind scooping the sand out, where it is not confined by the roots of the scanty vegetation that gains a foothold in some places. The myrtle bush (*Myrica cerifera*), the red cedar (*Juniperus virginianus*), the beach grass (*Psamma arenaria*), and a small creeping vine, are almost the only things that take root in these changing, arid sands.

The south shore of Long Island, from Nepeague beach to Southampton, is skirted with a line of sand-hills, presenting a very irregular broken appearance in the distance. Nepeague beach is covered for a considerable breadth with loose drifting sands, forming small hillocks of almost every variety of shape. The south beach of Long Island is almost entirely a line of hillocks, and is composed of a chain of long narrow islands of sand, from one to five or six miles from the main island.

The sand washed up by the surf, having dried on the beach, is borne inland by the wind, and piled up in heaps; and in some parts of the world, in consequence of the predominance of certain strong winds in one direction, they make a regular progressive movement, burying farms, houses, cities, and even whole tracts of country. No effects of this kind were observed on Long Island, of sufficient moment to affect the general value of farms, except in a few individual instances.

Should such causes ever threaten the destruction of property, their effects may be arrested by the cultivation of some plants which vegetate only in the most barren sands; by this means, their roots will confine the sand, and prevent its drifting. This course is pursued in some parts of Europe with obvious advantage.

The south part of Coney island is a labyrinth of sand-dunes, formed by the wind, which present almost every imaginable shape that such a material can assume. These hillocks are from five to thirty feet high, with a few straggling tufts of beach-grass, and clumps of bushes half buried in the drifted sands. They owe their origin to a tuft of grass, a bush, or a drift log, serving as a nucleus. As the grass grows, the drift sand settles among its leaves and partly buries it, and the process is renewed for years, until a sand hill is formed. On the contrary, where there is nothing to bind the sand together, or shelter it from the wind, it drifts away, leaving deep hollows. Drifted snow-banks afford an apt illustration of the sand-dunes of the Great South beach of Long Island, extending more than one hundred miles; and in a high wind we can there realize, in a small degree, the sand storms of the African and Arabian deserts.

Land Slides.

Many local changes on the surface of the earth, from the sliding of parts of hills or mountains into the valleys, have occurred, and examples of such phenomena are frequently attracting attention. Such facts are often made public when they have been attended by the destruction of life, or property; but thousands of such occurrences have taken place, as geological observations attest, which were either unknown, or of which no record has been preserved.

Land slides are the effect of one or several causes, acting conjointly:

1st. The action of water on soft crumbling or disintegrating strata, so as to undermine cliffs and leave them without sufficient support.

2d. Hydrostatic pressure of water in fissures.

3d. Hydrostatic pressure, and water rendering inclined beds slippery.

4th. Springs converting sands into quicksands, so that large masses flow from the cliffs and hills.

5th. The action of frost expanding the water as it freezes.

High cliffs of clay and sand on the sea shore and banks of rivers, which are undermined by water or by human labor, often crack at some distance from their edges, and stand upon comparatively narrow bases. If water filter into one of these fissures, its hydrostatic pressure is frequently sufficient to burst off the mass; and if the surface upon which it falls be inclined, it slides and tumbles to a greater or less distance, according to the nature of the materials forming it, and the quantity of water gushing out at the time of the slide.

The masses of earth or rock where the strata are inclined, are often raised by the hydrostatic pressure of water in the fissures of the strata seams, so that they slide off to a lower level. If, in such inclined strata, one of the beds be clay, the water renders it slippery, and the superincumbent mass slides off, unless it be supported. On some clay beds where slides have occurred, the angle of inclination is almost inappreciable to the eye.

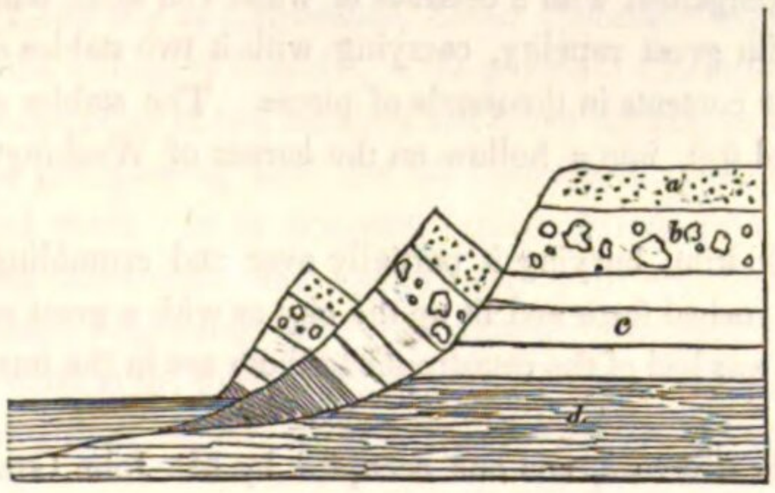
Many examples of slides from this cause might be adduced, as having occurred on the north coast of Long Island. In consequence of the sea washing away the base of the cliffs, large masses slip off, and sometimes slide into the sea. The washing away of the base of the

cliffs, conjointly with land springs, which in some localities convert the beds of sand into a quicksand, cause the mass of superimposed materials to flow off from the slippery clay beds.

Land slides on a small scale, are of very common occurrence on many parts of the north coast of Long Island. They are in some places caused by the sea undermining the cliffs, so that the superincumbent masses crack at a short distance from their edges, and slide down to a lower level, carrying with them trees and shrubs, and sometimes even without changing their relative position. These phenomena are common along the north shore in Suffolk county, but they are more striking and numerous where there are clay-beds, and particularly so, where the clay slightly inclines towards the sea. Where the cliffs are high, they present an appearance of steps, in consequence of the successive slides. (Vide fig. 1.)

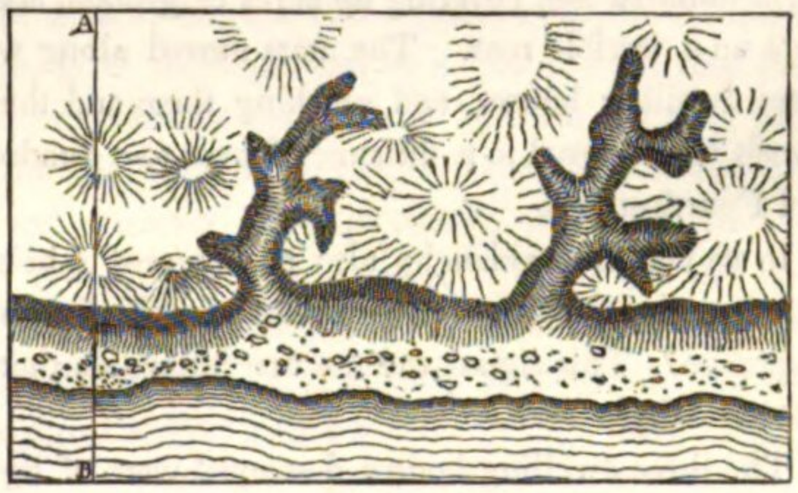
Another cause of slides is, the undermining action of land springs, which often convert sand into quicksand, so that it flows from the cliffs, and bears along with it the superincumbent masses; but in most instances they are caused by springs, rendering the upper surface of clay beds slippery, so that large masses from the cliffs slide down upon the shore, and even into the sea. Several acres have thus slidden off at once, and sunk in level from twenty to one hundred and fifty feet. By this means ravines of considerable extent are frequently formed. (Vide fig. 2.)

Fig. 1.



a Sand.
b Pebbles and boulders.
c Quicksand.
d Clay beds.

Fig. 2.



Topographical sketch, illustrating the effect of springs in forming ravines and slides on the north coast of Long Island.

Small slides have been observed about Albany, caused by springs rendering the clay slippery next the rock, which is frequently smooth, and allows large masses to slide into the ravines and valleys below.

The slides at Troy during the summer of 1836, and on the 1st of January, 1837, were also caused by springs of water. The locality at which these slides took place, presented a nearly vertical face of gravel and clay beds, of two hundred and twenty-seven feet in height. The upper part of the cliff probably cracked, and the land spring (which forms a considerable stream of water, and which from some unknown cause had been stopped,) filled the fissure,

rendered the clay slippery, and acting by its great hydrostatic pressure, burst off the cliff, which tumbled in huge fragments, sliding along as a mass of ruins, carrying every thing before it. The avalanche, after reaching the level ground, slid onwards about eight hundred feet, crossed one street and stopped at the second, crushing three houses and two barns, and destroying the lives of several persons, who were buried beneath the materials. The avalanche was accompanied by torrents of water and mud, rushing with a roaring noise over the fallen ruins. The fragments of the cliff form a very uneven surface of small irregular hills; the masses of clay are in huge fragments, with their layers placed at every angle of inclination and in every direction, and cover a surface about equivalent to two hundred yards in length by one hundred in breadth, and from ten to forty feet deep. By a moderate estimate, two hundred thousand tons of earth were thus transported to a distance of about two hundred yards.

The following extract is from the Troy Budget, and gives the details of this catastrophe.

Early last summer, a large mass of clay burst from the hill on the east section of the first ward of this city, followed by a gushing stream of water, and doing no other injury than covering a large portion of ground at the base with the bowels of the hill. Last evening about seven o'clock, a similar occurrence took place on the same spot, but, we regret to say, greater in extent and *exceedingly fatal in its consequences.* An avalanche of clay came tumbling from an eminence of nearly five hundred feet, moving down the base of the hill to level land, and then continued from the impulse it received to the distance of about eight hundred feet, covering up acres of ground, accompanied with a cataract of water and sand, which kept up a terrible roar. The mass moved along with great rapidity, carrying with it two stables and three dwelling houses, and crushing them and their contents in thousands of pieces. The stables and horses were moved to a distance of over two hundred feet, into a hollow on the corner of Washington and Fourth-streets.

In its way the avalanche also encountered a brick kiln, burying it partially over and crumbling it together, from which a few minutes after the flames rushed forth and lit up the city as with a great conflagration. This signal was the first intimation that was had of the catastrophe to those not in the immediate vicinity.

The three dwelling houses destroyed were of light structure, and one occupied by Mr. John Grace, another by Mrs. Leavensworth and the third by Mrs. Warner, the last of which was fortunately vacant at the time of the calamity. In Grace's house was himself and wife and a little boy, *the two former were extricated from the ruins dead,* and the boy was taken out alive, very little hurt, barefooted and bare headed, the building having been shattered in a thousand pieces; which is undoubtedly one of the most singular escapes that ever came to our knowledge. There were four of Mrs. Leavensworth's family in her house — herself and three children. Two of the children were in bed at the time, and probably asleep, and were afterwards taken from the midst of the wreck dead, crushed almost to a jelly, and were undoubtedly thrown instantly from a natural sleep into a sleep of death. Mrs. Leavensworth was taken out shockingly bruised, and was barely alive when we last heard from her. Fortunately three of the family were at church at the time, and escaped awful deaths.

In the stables were twenty-two horses, and all carried along with the mass, together with nine or ten dirt carts. Six horses were taken from the ruins alive — the other sixteen were killed. The dead bodies of the horses can this morning be seen mingled among the ruins.

We learn that the body of a person was found, name unknown, who was probably employed in the brick kiln or stables; which makes in all *five dead bodies* taken from the ruins last night. There are probably others buried among the ruins, as it is likely some persons at the time were in the stables or brick kiln.

The avalanche passed over a public highway which leads to the mill and nail factory, and might have carried along with it some straggling traveller. The clay is piled up in masses to the depth of from ten to forty feet over a large surface. It must have moved with great rapidity, and it is fortunate that it had not happened at the time when the laborers were employed in digging from the hill. At the time it was snowing freely, and this morning the scene was entirely covered with a white veil.

The scene that presented itself in the early part of the evening was awful in the highest degree. The horrors of an earthquake could not have presented a more dreadful spectacle. In the midst of a mass of convulsed earth, a multitude of human beings were moving to and fro; some carrying torches, and others digging among the ruins, and dragging from the midst the remains of some lifeless body, or were rescuing some one in whom life had not yet become extinct; some were crying "ho! ropes, ropes!" "help," "shovels," &c.; while the scene was dimly illuminated by the flames from the burning brick kiln, which is yet smouldering like an almost exhausted volcano. The scene must have been witnessed to be realized; we can give but a faint description of it.

Five large trees were precipitated from the hill, some of which are now standing erect at the bottom, and others in a slightly inclined posture.*

Land slip at Champlain, Lower Canada—On the 28th of August, at 3 o'clock, P. M., the inhabitants of the village of Hayolle, in the parish of Champlain, L. C. were alarmed by a tract of land, containing a superficies of two hundred and seven arpents, or acres, suddenly sliding three hundred and sixty yards, and precipitating itself into the Champlain river, which it dammed up for one thousand and three hundred yards. In its progress, houses, barns, trees, and whatever lay in its course, were overwhelmed. The catastrophe was accompanied by an appalling sound, and a dense vapor which filled the atmosphere, oppressing those who witnessed this phenomenon almost to suffocation. A man who was on the ground at the time, was removed with it to a considerable distance, and buried to the neck, but was extricated from his perilous situation without having sustained serious injury.†

Frost expands water in freezing, and causes the earth and rocks to crack, often bursting off huge masses from the mountain sides. If the sides of mountains be very steep and composed of loose materials over rocky but not very uneven surfaces, masses of matter falling upon them will sometimes communicate sufficient momentum to cause slides, which may be narrow at their commencement, but go on widening, until vast masses of materials rush onward, bearing along, overturning and burying up every thing in their course.

Land slips frequently block up rivers and streams in valleys, so as to cause lakes; and these sometimes bursting their boundaries, produce the most devastating effects.

A small land slide occurred near Claverack in Columbia county, a few years since, on the banks of Claverack creek, on the road from Hudson to that village, and about a quarter of a

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* Troy Budget, January 2, 1837.

† Boston Journal of Science, Vol. 1, p. 301.

mile from the bridge. During the night, about half or three quarters of an acre of ground slid forward into the creek, and pushed up a large bank of sand on the opposite side. The slidden ground sunk twenty-two feet below its former level. The substratum is a very saponaceous blue clay; and being undermined either by the stream, by land springs, or lying on the inclined slate rock, which seems most probable, slid to its present position. The clay is broken up and contorted in various ways, showing the lateral pressure to which it has been subjected. It occurred very near a house, and the underpinning of a barn on one side was carried away. Apple and other trees still grow and flourish as they did when the ground on which they stand was on a higher level. More of the land, of a rod or two in width, has slidden down since the first sinking of the mass.

Land slips are common in the clay beds between Hudson and Merino mountain, and in fact throughout the whole of this quaternary formation, where the action of streams, the sea, or other causes natural or artificial, have repeatedly exposed high banks of the clay, sand and gravel throughout the valleys of the Hudson and its tributaries, and the coasts of Lake Champlain, of Long, Staten and other islands in the First Geological district. The local examples known are too numerous to mention, and are of little interest more than their general results, viz. the degradation and washing away of these materials, to be deposited in some other locality.

Some examples of the sinking down of limestone rocks into caverns below, in consequence of the gradual removal of the limestone that supported the roofs of the caverns, by the solvent and erosive action of subterranean springs and streams, are here introduced.

Near Round pond, four miles southwest of West-Point, Orange county, the ground sunk down several feet, while Mr. Cronkite, the owner of the land, was digging a pit to bury potatoes for the winter. The subjacent rock was the white and flesh-colored limestone that occurs in that region, highly crystalline, and containing crystals of spinelle, augite, hornblende, phosphate of lime, brucite, hexagonal crystals of mica, etc. The fall of the rock exposed a cavern extending thirty or forty feet from the pit-fall, to which distance I explored it in various directions in 1825. The roof was studded with minute brilliant crystals of these various minerals. The cavern is nearly filled up since that time by wash, and by carting stones from the grounds around to prevent cattle from falling into it.

Another example occurred near Barnegat, Dutchess county, where the ground sunk, from the rock being no longer able to support the weight of the superincumbent mass. A man ploughing had passed over the ground that sunk, but a moment before.

Another occurred near Pine-Plains, on the line of a subterranean stream. Trees were not disturbed in their growth on the sunken ground; but a cow that was on it, died for want of water and food, from her inability to climb out of the sunken space.

The expansion of water, as it freezes in the fissures of rocks and cliffs, acts with irresistible force, detaching large blocks, which are daily falling in the winter and spring. In Greenland, the noise of such falls is said to resemble thunder.

Every one who has lived in a mountainous region, where high cliffs were near, must often have *heard*, if not *seen*, the enormous masses of rock tumbling and thundering down the

mountain side, crushing and bearing down every thing in their paths. In the winter of 1834, a large mass was burst off from a high cliff near West-Point, in the Highlands, by the frost, and fell with a report almost like thunder, and a jar like a slight shock of an earthquake, succeeded by a rumbling noise, caused by the rolling masses as they were precipitated down the mountain side.

Another fall, and from a similar cause, occurred a few years before the preceding, on the southeast side of Butter hill in the Highlands, from the face of a nearly vertical cliff. Many of the fallen rocks have been split up as a quarry stone, and used in building, and in the public works at fortress Monroe, and the Delaware breakwater. The masses still remaining, must weigh several thousand tons.

An observer may perceive hundreds of examples in the Highlands, where similar causes have produced the same effects. In fact, all the natural causes, affecting the geological structure of the earth, except mineral springs and volcanic action, tend to transfer matter from a higher to a lower level.

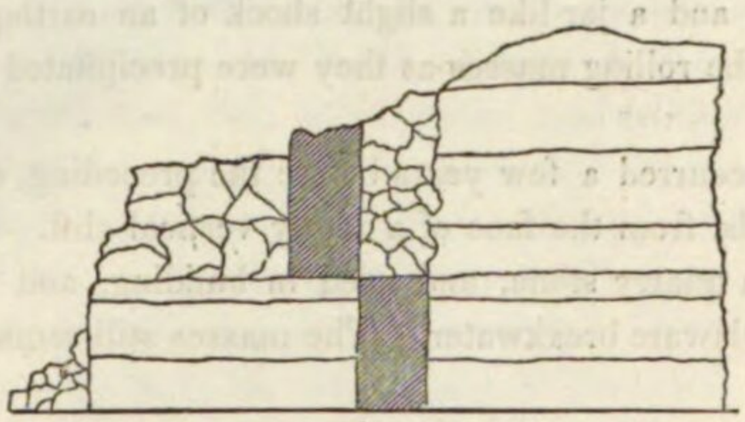
Disintegration.

The causes of alluvion belong to two great classes, viz, mechanical and chemical. The tendency of all rocks is to disintegrate and decompose, by the alternate action of heat and cold. Rocks that were angular, gradually lose their sharp edges, and become more or less rounded; and the soil of gravel, sand, loam or clay, resulting from this change, is partly washed or blown away by moving masses of water or by wind; and the general result is, that the land is constantly undergoing a state of degradation in some places, while the others are successively raised higher by the accumulated detritus deposited upon them.

The change of temperature is one great reason of the destruction of rocks. These masses are imperfect conductors of caloric; and the surface being heated or cooled more than the other parts of the mass, it undergoes a corresponding change of dimensions, and this with such force as to crack the rock. If, for instance, the surface be heated, it expands while the other parts remain stationary; but as stones are not elastic, and the force required to crush the expanding particles is greater than than required to crack it, the latter result follows. This principle is often employed in some parts of Europe, and even in this country, for splitting rocks, by building a fire on them, instead of using gunpowder. It is also employed in mines, where the rock is too hard to be drilled for blasting. This principle may be well illustrated it in a thick-bottomed glass bottle or tumbler; if it be suddenly heated by putting in hot water, a crack or fissure in the glass, from the unequal expansion, is the almost inevitable consequence.

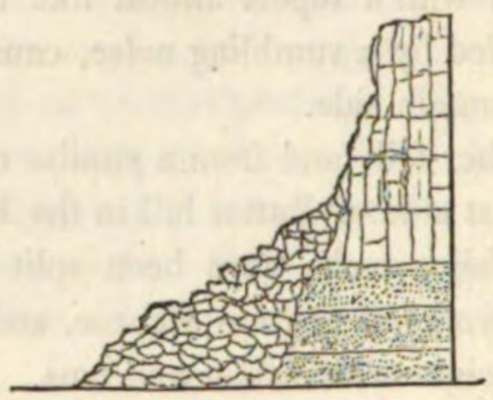
Again, in the winter season, the water that has filtered into the fissures produced by changes of temperature, freezes, and by its expansion opens the fissures still wider. All have seen the slope of fragments at the base of every rocky cliff, and many have heard or seen masses of rock tumbling down the mountains, loosened from their places by this cause. The annexed diagrams illustrate the above effects, in examples observed by myself:

Fig. 3.



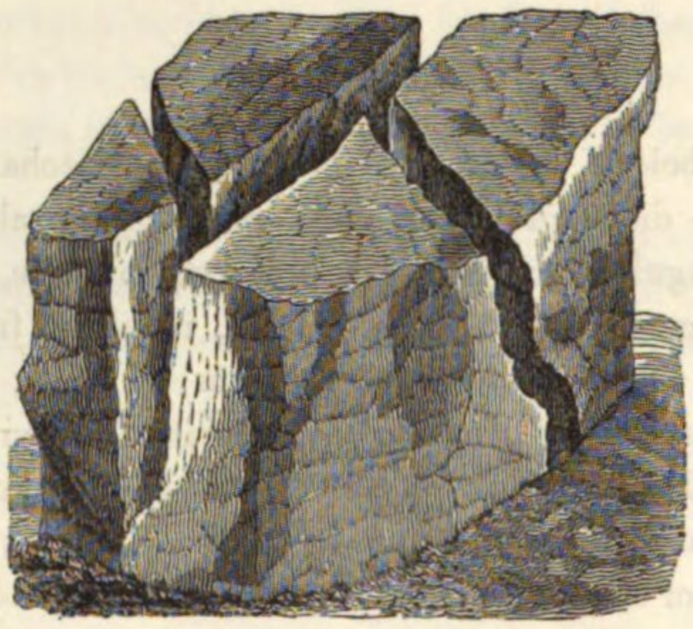
Granite vein heaved out of place by frost, Monroe county.

Fig. 4.



Trap and sandstone rock of palisades, with a slope of fragments at the base, burst off by the frost.

Fig. 5.



Rock split by frost.

Lightning is a cause, though in a very small degree, of alluvial deposits. It often strikes the rocks on mountain cliffs, shivering and tumbling them from their elevated situations into the valleys below.

Chemical agencies acting to decompose some one of the constituents of a rock, generally cause it to crumble and disintegrate. Granitic and trap rocks are most liable to this kind of disintegration, from changes of composition in the feldspar of one or hornblende of the other. The rocking stones, so many of which have been described in our country,* the piles of granite blocks in Cornwall, England, the rock basins called the Kettle and Pans, in the Scilly Islands, are all the effects of the combined chemical and mechanical causes of atmospheric influence.

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* Some in Putnam county are described in the American Journal of Science.

There is no rock which, if carefully examined after long exposure, does not show some traces of atmospheric action: the hardest siliceous rocks even show it. The effect of atmospheric action on cliffs of sandstone, in which the cement is of various degrees of destructibility, giving them such romantic and fantastic forms, is well known.

Crystalline limestone, from losing the cement that connected the grains, sometimes crumbles to sand. An example of this occurs near Sing-Sing, where the sand was at first used to mix in mortar for building, under the impression that it was siliceous sand. The building tumbled down, from no adhesion taking place. The white and dolomitic limestones of the counties of New-York, Westchester, Putnam and Dutchess, may be said to be characterized by crumbling on the surface by long exposure. In many localities they do not thus crumble, but very generally they are covered by materials derived from their own disintegration.

Causes of Disintegration.

There are several causes, which may act singly or conjointly, to produce a disintegration or crumbling of a rock.

1. Water may act so as to dissolve the cement which holds the grains of some rocks together, or one of the constituents of the rock.

2. Water, by means of various substances which it holds in solution, tends to decompose some one or more of the constituent minerals of various rocks, to form new combinations. Gneiss and granite frequently crumble to gravel, by the decomposition of the contained feldspar, and the rain and spring waters remove the potassa in the state of carbonate or sulphate.

3. The change of composition effected by atmospheric agents, as the change of oxidation of iron from a proto to a peroxide, for example, in basalt and trap; the decomposition of pyrites swelling and splitting the stone, and the excess of sulphuric acid resulting, acts as a decomposing agent upon other minerals in the rock.

Transport by floating ice.

Bakewell, in his Introduction to Geology, remarks, "Vast masses of rock near the seashore are sometimes enveloped in fields of ice, and raised up and transported to foreign countries. Ice is specifically lighter than water; every cubic yard will support a stone of one hundred pounds weight; hence we must not be surprised at the insulated rocks of granite that are sometimes found in situations far remote from primitive mountains. These blocks have been floated over the ocean, and their angular points and edges defended from attrition during their passage by the surrounding ice."

Dr. Hayden gives the following example, as coming under his own observation:

In the winter of 1780, memorable as the *hard winter*, and well remembered by many of the aged as the most severe since their recollection, the ice was frozen to a great thickness and solidity: in many places the water was literally frozen to the bottom. In the month of January, as usual, there came a great and

sudden thaw, accompanied by incessant torrents of rain, which appeared to spread over an immense extent of country. The consequences were such as might be expected; the snow, which was more than five feet deep, was quickly melted, every stream as suddenly became a river, and every river threatened to become an ocean. The Connecticut river was very soon raised almost to a level with its banks; and the ice, which was two feet and a half thick, was borne away by the current; and whenever it was impeded in its progress by an island, or the narrowing of the river, it was broken up, and immense masses raised in the air, until their elevated positions preponderating over their floating foundations, they were left to fall upon the surrounding ice, with a report equal in some instances to that of small pieces of ordnance.

This scene was extended for miles to the north and south; and while thousands were contemplating the noble spectacle, the ice, being very solid, and hurried on by a powerful current, became obstructed at the straits near Middletown, and the whole force of the river for a short time was impeded; the water set back and upwards; enormous masses of ice were hurried over the banks of the river into the creeks and larger streams to a considerable distance into the meadows and low grounds; when on a sudden, in consequence of the pressure from above, the obstruction at the straits gave way, and this threatening appearance vanished in a short time; the water fell to its natural state, and left huge masses of transparent ice in the meadows and intervales, to be removed only by the powerful influence of a summer's sun. When this was accomplished during the following season, large pieces of rock and heaps of rolled pebbles were left exposed to view on an alluvial surface, on which before a stone could not be found for its weight in gold.*

The alluvial flats along the Hudson, in many places, have boulders and angular masses of rock scattered over their surfaces, that have been brought by the floating ice in the spring, and deposited as the ice thawed. The meadows between Hudson and Catskill may be given as examples.

Transport by ice up the banks of streams above water level.

"On the breaking up of the ice of the Hudson, on the fourth of March, 1822, many cakes loaded with gravel lodged on the shore at Troy near the sloop lock. Other cakes of thick strong ice came continually crashing against and sliding over those already there, driven onwards by the swollen river, and pushing each other up the river bank; so that when the ice had thawed, several hundred cartloads of gravel were left at a level thirty-four feet higher than the greatest height of the water at the time of its deposit." †

Similar facts, but less striking, may be observed at every breaking up of the ice, where the current forces the ice against the shore.

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* HAYDEN, Geol. Essays, p. 87, 89.

† EATON, Am. Jour. Science, Vol. 5, p. 22.

Blocks transported by Ice.

Bigsby, in describing the geology of Lake Huron, remarks,

"In the spring, the ice removes fragments of great size. In the winter it surrounds those which are placed in the shallows; and on being broken up by the mild weather of spring, by the rise of water which takes place in consequence of the blowing of the wind, they are either carried higher on the shore, leaving a furrow behind them, or they are moved off with the field of ice to which they are attached, and on the melting of the ice, deposited on some other shore more or less distant from their original situation. Rounded rocks of *some yards in diameter*, are thus removed."*

"There is a curiosity to be seen in the Long pond in Bridgeton. In a cove on the east side of the pond, the water is so shoal that a man may wade fifty rods into it. On the bottom of this cove are many stones of various sizes, which have an evident annual motion towards the shore. The proof of this is, the tracks or furrows left behind them, and the clay driven up before them. Some of the stones are two or three tons weight, have left a track several rods behind them, and have at least a cartload of clay piled up before them. Some of them are covered with water all the year. The shore of the cove is lined with these stones three feet deep, which, it would seem, have crawled out of the water." †

Similar facts have been observed in Salisbury in Connecticut, and other places;‡ and by attentive observation, may be seen in many of the small lakes in New-York.

Explanation of the cause. The explanation of this fact is, that in the winter the rocks are enclosed in thick firm ice, which in freezing expands from the centre towards the shores, thrusting the rocks along with a powerful force, ploughing the earth up before it, and leaving a corresponding furrow behind. Another and principal cause is, that when the ice begins to thaw in the spring, the powerful winds elevate the waters rather above their usual level on the leeward side; thus, the ice lifts the enclosed rocks, and the wind drifting it towards the shore, produces the same effect as in the other case. The ice thaws first around the shores of ponds, and is thus anchored by means of its attached rocks, and the winds cause it to drag the stones along the bottom.

Another cause of these effects is, by the thawing of the snow during the spring and latter part of winter, much surface water finds its way into the lake, and its surface is raised some inches or feet above its usual level. The ice continuing to float, raises or buoys up such masses of rock as are not too firmly fixed, or too heavy to be sustained by the strength of the ice, and floated off; and when they ground, they plough up the earth before them, and leave a furrow behind.

Ground Ice.

The ice called *ground ice*, is also a powerful means of transport for blocks, pebbles, gravel and sand. It forms in water during cold weather, at the bottoms of streams and lakes; and

* American Jour. of Science, Vol. 3, p. 256.
† Collections of Mass. Hist. Society, Vol. 3, p. 240.
‡ Am. Jour. of Science, Vol. 5, p. 34; Vol. 9, p. 136. Dwight's Travels, Vol. 5, p. 34.

when it has accumulated to such a thickness as to buoy up the attached masses of rock and earthy materials, it rises to the surface, and transports its load by means of currents or winds to distant places. It is ascertained that ground ice forms in water of more than one hundred feet in depth.

No explanation of the formation of this ice, upon scientific principles, has yet been given. The following is offered as probable :

Ice, when rotten in the spring, becomes saturated with water, and then *sinks*. This proves that ice is properly heavier than water, and that its less specific gravity is only due to the crystalline arrangement leaving vacuities. Again, in water cooled below the freezing point, and then agitated, a portion of the water freezes into minute spiculæ, which float in the water without rising to the surface ; and if the water be then kept still, they sink, and form a layer on the bottom of the vessel. Now the water of rivers and the sea may be similarly affected in a degree ; the spiculæ forming into masses on the bottom, and cementing the gravel, enclosing rocks, and finally, by a similar crystalline arrangement, form interstices which render the mass of less specific gravity than the surrounding water, and thus rise with rocks and gravel adhering.

Fairhaven falls destroyed on the Poultney river, by which a part of New-York was thrown into Vermont. In one night, one man is said to have set the stream to remove what millions could not replace. The fine navigable Fairhaven bay, nine miles in length, was turned into flats and shallows where no sloop can enter. The fish were all killed by the feculent flood.*

Excavating action of Water on Soft Strata.

It is well known that even the smallest streams excavate deep channels, in soft and destructible soils, in a short time. The erosive action of water may be well seen in the rocks worn into pot-holes, many feet above the Mohawk river, at Little-Falls ; also at the falls of the Hoosick in Rensselaer county, and at numerous other places. These holes, often many feet in depth, and shaped like a well, are formed by the water-current keeping a hard pebble performing a rotatory or a rolling motion, and thus wearing a deep hole in the rocks. They may be found at the falls or in the rapids of almost every large stream, if examined when the water is low.

Alluvial Deposits.

The effects of a powerful storm of rain at Catskill, on the twenty-sixth of July, 1819, were very marked. The rain was so great in quantity, that from fifteen to eighteen inches in depth is supposed to have fallen in a short time. From the banks of a small brook which crosses the western turnpike, about a quarter of a mile above the north end of Main-street, "some thousands of tons of earth and stones and rock in solid masses were washed out, and borne chiefly on to the flats," or left within the area between the banks.†

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* Geddes, in Sill. Journal, Vol. 11, p. 217.

† Dwight, in Sill. Journal, Vol. 3, p. 132.

On a plain near Catskill, called Jefferson plain, the ground was covered with water to such a depth that it covered the floors of many barns several inches deep; and on a field of about thirty acres, the water accumulated to a depth of about eighteen inches, and it was so situated that it could not derive it from adjacent grounds. This water nearly all flowed off at one place, and formed a gully, which at the edge of the plain was about one hundred and ninety feet broad, and between eighty and ninety feet deep. Several other ravines were formed in a similar manner in the loose materials, sand and gravel which formed the plain. One of them was ninety yards long, two to six rods wide, and ten to forty feet deep.

At Wolcott's mills, two large gullies were formed near each other. The eastern gully is twenty rods long; it is about two rods wide at the commencement, and ten or twelve feet deep, and lays bare a ledge of red sandstone rock. When this gully was formed, the current ran directly against and by the side of a house. A man, in stepping from the door to remove a sick woman, and where the water was supposed to be about two feet deep, was precipitated into the deep water formed by the current washing away the soil, and was hurried onwards by the turbulent flood, and drowned. A vast quantity of earth, stones and rocks, some of them more than a ton in weight, were washed down the gully into the creek, and now form a bank one hundred feet long, seventy broad and eight or ten feet deep, above the former bed of the stream. There was no stream previous to the storm, where this ravine was formed.

The western gully was occasioned by the prodigious rise and enlargement of a small brook, the usual width of which does not exceed a yard. A plaster mill, grist mill and large distillery were undermined and borne away on the flood, and the deposit of rocks and pebbles greater than from the other ravine. It is one hundred and eighty feet long, one hundred wide, and five or six deep.*

Many other interesting details of the same storm, removing rocks of many tons weight, causing slides on the hills, etc. are described.†

Alluvial action on Black creek, Ulster county. Evidences of recent alluvial action are manifest in the valley of Black creek, about one mile south of Esopus. The heavy rains of April, 1839, produced great devastation throughout this part of the country. At the place mentioned, and for half a mile above, the flats along the creek were covered with beds of gravel and sand from two foot to five feet deep, the old bed of the stream was entirely filled up, and the creek was scooping out a new channel, at the time of my visit, through the beds of alluvion which it had so recently deposited. A mill-dam half a mile above the bridge where the river road crosses Black creek, was washed away, and the bed of the creek cut down more than twenty feet lower than it was before, so as to leave the bed of the old mill-pond high and dry twenty feet above the level of the present bed of the creek. From this deep new cut of the creek, and the extensive slides of the high steep banks of gravel and sand, the alluvial matters spread over the meadows below have been derived.

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* DWIGHT, Sill. Journal, Vol. 3, p. 135.

† ID. Vol. 3, p. 136 *et seq.*

Logs and trees are frequently exposed in the bed of Kinderhook creek, where it wears away its banks or shifts its channel. Dr. Pruyn related several examples where these things had thus been exposed, after having long been buried in the alluvion, that had come under his personal observation. Similar observations have been made by residents on the banks of the Schoharie kill, of the Batten kill near Cambridge, the Hoosick, and various other streams.

Trees, logs, timbers, planks, and various products of nature and of art of the present day, are continually being enveloped and buried under the alluvial depositions along the valleys of streams, in marshes, lakes, ponds, and on the coast; and all future change tending to remove these deposits, will expose some of the buried objects, as the removing agencies now expose the deposits of preceding times.

Bones of Animals in Alluvial Depositions.

The bones of the Mastodon, and of the Fossil Elephant, are frequently found in the peat bogs of Orange county. Many parts of skeletons have been obtained from thence; and multitudes of individuals of these animals are undoubtedly entombed in the marshes of that and perhaps other counties. Few of their remains have been found further north. Orange county abounds in peat and marl marshes; and from the position in which the bones of many of their skeletons have been found in New-York, Ohio and Kentucky, it is inferred that most of these animals (whose remains we find) lost their lives by being mired in the marshes and in the miry clay around the salt licks of southern Ohio and Kentucky.

Some of the bones of a fossil elephant, as is supposed, were found about two miles west of Greenville, Greene county, about twelve miles from Coxsackie. Two of the vertebræ were brought to Albany. One of them, the *dentatus*, is still in the possession of Prof. E. Emmons. The articulating surface of this is nine inches in diameter.

Another was found on the Helderberg mountain, in a bed of shell or lake marl, where it appeared to have been mired in this material, on the bank of a small pond-hole or marsh. This was found on the farm of Mr. Shear, four or five miles west of the Hudson, in the township of Coeymans, Albany county. A tusk of the animal was brought to Albany. Most of the skeleton is supposed to be still at the locality where the tusk was found. The tusk was small for one of these animals.

Mr. Peale, the naturalist, obtained most of the bones of a skeleton of a mastodon from one of the marshes in Orange county. In Goldsmith's Natural History, edited by Godman, may be found a detailed account of the places explored, and the difficulties encountered and overcome in procuring them.

Nothing is known with certainty of the habits of these animals,* farther than can be drawn from investigations of comparative anatomy; and no one who has examined into that subject,

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* Mr. Stickney, for many years Indian Agent for the United States for the Indians northwest of the Ohio, and who, from his long residence among them, became intimately acquainted with their customs, habits, manners and traditions, informed me that particular persons in every nation were selected as the repositories of their history and traditions; that these persons had others

has any doubts of the certainty of its indications in demonstrating the habits and general characters of animals, when subjected to the investigations of an able comparative anatomist.

To the Baron Cuvier, we are indebted for a large share of the knowledge of comparative anatomy that we possess, and almost exclusively for an application of the principles of that science to fossil bones. The laws that regulate the forms of the various parts of animals are well illustrated by Cuvier. He remarks:

"Every organized being consists of parts which correspond mutually, which concur by means of reciprocal influences in the production of a common end, and thus form together a whole, a perfect system. No one part can change without the others being modified; and consequently each, taken separately, modifies all others."

If the intestinal structure of an animal be fitted only for digesting flesh recently killed, its jaws must be fitted to devour, its claws to seize and tear, its teeth to cut and divide, and its entire system of organs and limbs for pursuing and catching its prey, and the perceptive faculties must be fitted to discern that prey afar off. It is necessary also that he should have seated in his brain the instinct to hide himself, and spread snares for his victim. Such are the conditions necessary for every carnivorous animal; without them the species could not subsist.*

"Besides these general conditions, there are subordinate ones, relating to the size, the species, and the abode of the prey; and each of these secondary conditions give rise to differences of detail, in the forms which result from the general laws. Hence not only the class, but the order, the genus, and even the species are expressed in the form of each part."

A jaw of a certain force must have a suitable articulation, and a sufficiently large temporal muscle, indicated by the hollow formed in the bone for its reception, and by the convexity of the strong zygomatic arch. An animal which carries off his prey, must have strong muscles to elevate the head; and the parts of the vertebræ and of the occiput to which they are attached, must have a form to correspond with this intention.†

"For dividing flesh, cutting teeth are required; and they must be more or less cutting, in proportion as they are more or less exclusively occupied in that way. Their basis must be solid if they are employed in breaking and comminuting bones, particularly if the bones are strong. These circumstances will influence the development of all the parts employed in moving the jaw."

"Mobility of the toes, and strength of the nails, are necessary for seizing the prey; hence arise determinate forms of the phalanges, and particular distribution of the muscles and tendons. There must be a power of rotating the forearm, and consequently a particular

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who were younger, selected for this purpose continually, and repeatedly instructed in these things which were thus handed down from generation to generation; and that there was a tradition among the Indians of the existence of these animals; that they were often seen; that they fed on the boughs of a species of lin tree; that they did not lie down, but leaned against a tree to sleep.

* Bakewell's Geology, 2d Am. Ed. p. 230.

† Museum of Foreign Literature, Vol. 26, p. 215.

form of the bones composing it; and as the latter are articulated to the humerus, any alterations in them must alter its figure. Animals which employ their fore limbs in seizing, must have strong shoulders; the scapula and clavicle will therefore exhibit certain modifications. The muscles must have forms, size and strength suitable to the actions of which the bones and joints just enumerated are capable, while their attachments and contractions impress particular figures on those solid organs."

"Similar conclusions may be drawn respecting the posterior extremities, which contribute to the rapidity of the general motions; respecting the composition of the trunk, and the form of the vertebræ, which influence the facility of these motions; respecting the bones of the nose, of the orbit and the ear, which have obvious relations to the degree of perfection in the senses of smelling, seeing and hearing. In a word, the form of a tooth determines that of the condyle; the form of the scapula, that of the nails; just as the equation of a curve indicates all its properties. As in taking each property separately for the basis of a particular equation, we might arrive not only at the ordinary equation, but at all the other properties of the curve; so the nail, the scapula, the maxillary condyle, the femur, and all the other bones taken separately, would each indicate the kind of teeth, or would indicate each other reciprocally; and beginning with either separately, we might, according to the rational laws of the organic economy, reconstruct the whole animal."*

If the geologist find the nearer head of the radius of some animal, and see in its extremity a smooth depression where it bears against the humerus, and observe the polished circle where it rotates on the cavity of the ulna, he would say, this animal had a paw; it had a motion at the wrist, which implies claws. Claws may belong to two orders of animals, viz. feline, having carnivorous teeth; or to animals without teeth. If he should find the lower extremity of the same bone, and observe on it spines and grooves for the distinct tendons which disperse to the phalanges, he would conclude that the animal must have had movable claws; that it was carnivorous, and he would seek for the corresponding canine teeth.†

Again, suppose the bone found be the humerus, and on examination it proves to have a round head, and the tubercles near this head are depressed so as not to interfere with the revolving motion; such a form betokens a latitude and extent of motion. But freedom of motion in the shoulders implies also freedom in the extremity or paw, and rotation of the bones of the wrist. We now examine that part of the humerus which gives rise to the muscles for turning the wrist (supinator), and in the prominence and length of the ridge which is on the lower and outer side of the bone, we have proof of the free motion of the paw. We conclude, from the bone thus characterized, that it belonged to an animal with sharp movable claws, and "that in all probability it is the remains of a bear."

Suppose, again, that the head was not so round as in the last case, and that the tubercles project so as to limit the motion. On such a humerus we shall find on the lower end a hinge

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* Recherches sur les Ossemens fossiles, Prel. discours; Cuvier, Anat. Comp. Vol. 1, p. 45; Bost. Journal Science, Vol. 1, p. 261; Mitchill's Am. Ed. of Cuvier.

† Bell on the Hand.

joint, and there will be no signs of the rotation of one bone of the forearm on the other. These characters indicate "an herbivorous quadruped, either with a solid or cloven foot."*

Mastodon.

Of all the remains of mammiferous animals investigated by Cuvier, those of the Mastodon, or the Mammoth, as it is frequently called, are to us of peculiar interest, in consequence of their common occurrence in our country, of their great size, and of their being the first which convinced naturalist, beyond all doubt, that animals had formerly existed whose species are now extinct.

The term *mammoth*, usually employed in this country in common language, does not strictly belong to the Mastodon; and it arose in the first place from a mistake of Dr. W. Hunter,† who, on examining some bones of this animal, concluded they were of the same kind as those found in Siberia, and which were believed by the inhabitants of that country to belong to a large unknown animal, called Mammoth, and which has since been proved to be a species of Elephant. Cuvier, after investigating the anatomy of both these animals, inferred that they were distinct, not only in species but in genus. He gave the name *mastodonte* to the American animal, from the peculiar form of its teeth. The term *mammoth* is retained for the Siberian animal, which is a species of elephant.‡ Teeth of the mammoth or fossil elephant, have been found in the United States, in connection with those of the mastodon, and are, perhaps, as abundant.

The earliest records that we have of the bones of these animals, the mastodon and the fossil elephant or mammoth, is believed to be the letter from Cotton or Increase Mather to the Royal Society of London, between 1650 and 1700, describing the bones of one of these animals as found near Albany. It is perhaps unnecessary to dwell upon the inferences from the discovery of these bones, farther than to state, that in those times when comparative anatomy was unknown, they were supposed to be the remains of a huge giant. They have since been found in almost every part of our country except New-England, but perhaps in greater abundance in New-York, Ohio, Kentucky, Indiana, Illinois and Missouri, than in other parts. Their remains are found only in the alluvial deposits, and most frequently in deposits of peat, lake or shell marl, in the banks of streams, or in the vicinity of salt licks, or where saline substances exude or effloresce from the earth. Such places have been in former times, and are still in the more sparsely settled parts of the country, the resort of wild animals to lick the clay, and frequently the more feeble and diseased die in the vicinity.

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* Bell on the Hand.

† Phil. Trans. Vol. 58, 1767.

‡ Boston Journal, (Dr. Ware,) Vol. 1, p. 257; Anatomy of Mastodon (by the same,) Bost. Journal, Vol. 1, p. 391.

INFUSORIA.

These microscopic animals inhabit the waters of streams, and of salt and fresh water ponds and marshes. In many places they have left masses of their remains, that have accumulated in course of time, so as to form important geological deposits. It is but a few years since it was first known that these minute animals composed the mass of the white pulverulent earth so common in the bottom of pond-holes and marshes, in which water stagnates during the warm season of the year. I first became acquainted with this material, while making a geological survey of New-London and Windham counties in Connecticut, in 1831. It had been used for many years as a polishing powder, to polish brass, silver, etc., and had been packed in small parcels and sold for that purpose in the country around. I supposed it to be lake marl, until an acid was applied, and found that it would not effervesce; and on making an examination, found it to be siliceous. I did not then know that it was secreted by animals to form their coverings, but supposed it to be derived from the decomposition of the surrounding primary rocks.

The discoveries of Ehrenberg have led to investigations in various parts of the world, and very numerous localities of this infusorial earth are now known in New-England, New-York, and some in other states. This earth, so far as my observations have gone, leads to the conclusion that it is found more abundantly in primary regions than in others. Many of the bog meadows and stagnant ponds in the Highlands contain it. Prof. J. W. Bailey, my successor as instructor of mineralogy and geology in the United States Military Academy at West-Point, has investigated the subject of fossil infusoria with much zeal and success. He has had the kindness to furnish me with the following results of M. Ehrenberg's examination of some fossil infusoria sent him by Professors Silliman, Hitchcock and Bailey, and Prof. B. has added remarks of his own.

Ehrenberg, on the 25th March, 1841, made a communication to the Berlin Academy, giving results of his examination of American Fossil Infusoria received from Profs. Silliman, Hitchcock and Bailey. He states,

1. That in North and South America occur not only living but fossil microscopic organisms, geologically important in thickness and extent, and very similar in their relations to the European.
2. The American forms are for the most part similar to the European.
3. One hundred and forty-three American species are common to Europe, and seventy-one, or one-third, peculiar to America.

4. Not one of the American infusorial deposits is, in its elementary forms, similar to those which form the chalk marl in the south of Europe; nevertheless there is found in the deposit near Spencer in Massachusetts, the Rotalia globulosa, which is decidedly peculiar to the writing chalk.*
5. The greater part of the fossil deposits in North America occur under peat banks, and belong also, by their elementary forms, clearly to the brackish fresh water forms of the sea coast, although some of them lie a long way from the sea coast.†
6. It is remarkable that as far as these observations extend upon the earth, the very peculiarly formed many-toothed, diadem, and saw-shaped Eunotia are met with only in the United States, Sweden and Finland, and no where living.‡ On the contrary, the Spongia phillipensis is observed only in Lucon and Eastern North America, both in fossil deposits; these places differing as much in climate, as the former correspond.
7. The following is Ehrenberg's catalogue of American Bacillaria, Polythalamia, &c.:

A. Fossil.

Amphiphora navicularis.
Cocconema arcus.
— lunula.
Eunotia amphioxys.
— biceps.
— bidens.
— monodon.
— prærupta.
— uncinata.
— zebrina.
Fragillaria constricta.
— pinnata.
— paradoxa.
Gomphonema americana.
— lanceolatum.
Gomphonema nasutum.
— undulatum.
Hemantidium gracile.
Navicula americana.
— amphigomphus.
— amphioxys.
— bacterium.
— baileyi.
— costata.
— decora.
— dilatata.
— grammatostoma.
— hitchcockii.
— legumen.
Navicula oblonga.
— porrecta.
— pumilis.
— silicula.
— sillimanorum.
— tumidula.
Tabellaria amphilepta.
— nodosa.
— biceps.
Spongia ramosa.
— serpentina.
— setosa.
Thylacium ossiculum.
— semiorbiculare.

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* The statements of Ehrenberg in this paragraph contain two errors, which he had not the means of correcting:
1. The infusorial deposit of the tertiary of Virginia, I have shown to contain all the predominant *siliceous* forms of the chalk marls of Oran, Caltasinelta, etc.; forms which I have also recently detected living, both at Boston harbor and in the Hudson at West-Point.
2. The Rotalia globulosa, found by Ehrenberg in the siliceous marl from Spencer, Massachusetts, must have been introduced accidentally from a particle of chalk, or from the use of impure Canada balsam which had been used in examining chalk. I can confidently assert that neither Rotalia globulosa, or any other calcareous polythalamian form, occurs in any of our bog deposits of infusoria. J. W. B.

† I have seen all the principal forms, in a living state, as far west as Ouisconsin river near Fort Winnebago, and therefore cannot consider brackish water as at all necessary to their existence. J. W. B.

‡ These all occur in a living state at West-Point. J. W. B.

B. RECENT.

Achnanthes pachypus.
Actinocyclus hexapterus.
Cocconeis oceanica.
Dictyocha panduriformis.
— splendens.
Echinella moniligera.
Fragellaria catena.
— pinnata.
Gomphonema subtile.
Grammatophora mexicana.
Navicula campylodiscus.
— bicarinata.
— crucigera.
— læta.
— reticulata.
Podosira moniliformis.
Spongia capitata.
Spongia clara.
— neptuni.
— obtusa.
— uncinata.
Globulus porosus.
Spirulina vivipar.
Biloculina tenella.
Textularia plicata.

The following papers of Prof. BAILEY, upon the subject of the Infusoria, are from the American Journal of Science, Vols. 41 and 42:

Those organized beings which EHRENBERG has placed among the Infusoria, in the family Bacillaria, present almost equal claims on the attention of the zoologist, botanist, and geologist. Containing, as this family does, those obscure organic bodies which form, as it were, the connecting links between the animal and vegetable kingdoms, and which appear to possess characters belonging to both, the student of either zoology or botany must examine them; and, in fact, the very simplicity of their structure renders them peculiarly proper for the observation of many phenomena of great physiological interest. The geologist must attend to them; for the discoveries of Kützing, Fischer, and especially of Ehrenberg, have shown that many of these minute bodies possess siliceous coverings, which occur in vast abundance in the fossil state, and which form the minutest, and yet not the least important nor least interesting, of the series of "nature's medallions."

Believing that some account of the structure, classification, etc. of this family would be acceptable to many in this country, and that figures of our most remarkable species would be of interest to the students of this family, both in this country and in Europe, I have devoted for some time past the very few leisure hours at my command, to the preparation of the following sketch. As an apology for the very imperfect state in which I now present it, I must state that my knowledge of the labors of others is necessarily very slight, as it is almost impossible to procure in this country any works relating to this branch of natural history. Of the many European works which contain figures of these obscure beings, scarcely one has been at my command; and as no one in this country has previously studied this subject, I have had to trust almost entirely to my own observations.

To avoid the risk of adding to the already burdensome synonimy, I have not attached any names to the species which I believed new, or which I could not determine satisfactorily, and shall merely refer to them by the numbers given to the figures representing them. I hope that these figures will enable some of the learned students of this family in Europe to decide which species are new; and perhaps if this paper should meet the eyes of Ehrenberg, he may oblige us by furnishing the authentic names of the species represented in the accompanying plates.

For what relates to the classification and synonimy of this family, I am chiefly indebted to an abstract of Ehrenberg's work on Infusoria, which is appended to Mandl's *Traite pratique du Microscope*. The generic and specific characters which I give, are in most cases literal translations from this work. I have also studied with much profit, Kützing's *Synopsis Diatomearum*, in the *Linnæa* for 1833. The plates accompanying Kützing's memoir have decided many doubts for me. Ehrenberg's great work on Infusoria I have not yet seen.

Without further preface, I shall now present a translation of Ehrenberg's characters for the family

BACILLARIA.

Polygastric (distinctly or probably), without intestinal canal; appendices (distinctly or probably) variable, undivided; body multiform; carapace often prismatic and siliceous, with one or several openings, often having the form of articulated polypidoms, in consequence of imperfect, spontaneous (longitudinal) division.*

Ehrenberg divides this family into the following group, viz:

DESMIDIACEA, having the carapace simple, free, and univalve, (not usually siliceous.)
NAVICULACEA, with the carapace simple, free, with two or more valves, (siliceous.)
ECHINELLEA, with the carapace simple, fixed, (siliceous.)
LACERNATA, with the carapace double, (siliceous, and enveloped in tubes or gelatine.)

He separates the Closteria as a distinct family; but this genus is so closely allied to Euastrum, that I cannot hesitate to follow the example of most writers upon the subject, and to class them with the Desmidiaceæ.

The following analytical table of the genera of Bacillaria, is translated from Ehrenberg:

A. CARAPACE SIMPLE.
- a. Free.
  - a. Univalve, ... *Desmidiacea.*
    - *a.* Prismatic.
      - 1. Trilateral, ... Desmidium.*
      - 2. Qaudrilateral, ... Staurastrum.*
      - 3. Pentagonal, ... Pentasterias.*
    - *b.* Round.
      - 1. Smooth.
        - aa. Polypidoms moniliform, ... Tessararthra.
        - bb. " bacciform, ... Sphærastrum.
      - 2. With projections, ... Xanthidium.*
    - *c.* Flattened.
      - 1. In forms of bands.

* The question as to the correctness of Ehrenberg's view with regard to the internal structure of his Polygastrica, appears still undecided.

aa. Serrated, ... Arthrodesmus.*
bb. Not serrated, ... Odontella.*
2. In the form of discs or plates.
aa. Several in each disc, ... Micrasterias.*
bb. Two in each disc, ... Euastrum.*
cc. Isolated in plates, ... Microtheca.
b. Two or more valves, ... *Naviculacea.*
a. Round.
1. Globular, ... Pyxidicula.*
2. Forming polypidoms.
aa. One cell, chain filiform, ... Gaillonella *
bb. Several concentric cells, ... Actinocyclus.*
b. Prismatic.
1. Division perfect, never forming bands.
aa. With six (?) openings, ... Navicula.*
bb. With four openings, ... Eunotia.*
cc. With one opening, ... Cocconeis.
2. Division imperfect, forming bands.
aa. Articulated.
aa. Prisms ("baguettes"), ... Bacillaria.*
bb. Plates, ... Tessella.*
bb. Without articulations.
aa. Strait ribbands, ... Fragillaria.*
bb. Spiral ribbands, ... Meridion.*
B. Fixed, ... Echinella.
a. Wider than long, ... Isthmia.*
b. Longer than wide.
a. Without a pedicel.
1. Prismatic, ... Synedra.*
2. Wedgeform, ... Podosphenia.*
b. Supported by a pedicel.
1. Wedgeform.
aa. Dichotomous, ... Gomphonema.*
bb. Verticillate, ... Echinella.*
2. Fixed perpendicularly, ... Cocconema.*
3. Fixed obliquely.
aa. Opening in the middle, ... Achnanthes.*
bb. Without opening in the middle, ... Striatella.*
B. CARAPACE DOUBLE, ... *Lacernata.*
A. Surrounded by an amorphous gelatinous mass.
a. Scattered, ... Frustulia.
b. Joined in rings, ... Syncyclia.
B. Surrounded by membranous tubes.

a. Tubes separate.
  a. Frustules strait, ... Naunema,*
  b. " curved, ... Gloenema.
b. Tubes joined.
  a. Fasciculate, ... Schizonema.*
  b. Branching, ... Micromega.

The genera marked thus (*) have been detected in the United States.

Ehrenberg remarks of this family, that "the organization is difficult to recognize, in consequence of the hardness and refraction of the carapace. None have yet been found with calcareous coverings, but they are either hard and siliceous, (sometimes containing a little iron,) or membranaceous without silica. The differences observed in the forms of the carapace have been made use of in classifying them (see preceding table). In several genera, are found internal hyaline vesicles of variable form; these are colorless, and resemble the stomachs of the Polygastrica, and in recent experiments they have been colored by means of indigo. The female organs consist of colored or colorless granules, forming two or four groups, which are placed near the middle of the body, as in Navicula, Cocconema, Naunema, &c. These eggs are frequently divided into several globular groups, which finally unite in a cruciform manner (Achnanthes), or which become confounded together before being emitted (Gaillonella, Pyxidicula, Isthmia, &c.); at other times they appear under the form of a tube enveloping the stomachs and other organs (Xanthidium, Euastrum, Micrasterias). The genera Micrasterias, Arthrodesmus, Tessararthra and Xanthidium, have organs which may be compared to seminal vesicles. Spontaneous division produces much variety in the forms of the polypidoms. It sometimes takes place longitudinally, sometimes transversely."

The living species of this family may be found in almost every situation where water occurs upon the surface of the earth. Some genera are exclusively marine, others are exclusively fluviatile; while some genera, as Navicula, Gomphonema, &c. include both salt and fresh water species. The marine species may often be found in great quantities among the filiform algæ, which they often invest completely with their crystalline carapaces.

The fluviatile species may be found in every pond, stream, rivulet, bog, or pool, either nestling among confervæ, parasitic on aquatic plants, or living in the sedimentary matter at the bottom. They often occur in such vast quantities as to cover hundreds of square yards, to which they give a peculiar color: green, yellowish or ferruginous, according to the peculiar internal coloring matter of the individuals. Most of the species are exceedingly minute, many are entirely invisible to the naked eye; others, however, are quite perceptible without the aid of the microscope. Notwithstanding their extreme minuteness, it is evident, from their vast abundance, that they have some important offices to perform in the economy of nature; and like the coral insect, although the individuals are minute, the result of their united labors is on a scale by no means insignificant.

Few organic bodies exceed in beauty the symmetrical, elegantly sculptured forms of many of the species. Their beauty, the singular phenomena they present, and the interest they

have lately received from being detected in a fossil state in Europe and America, will be sufficient inducement for all lovers of microscopic research to study this family.

I shall now proceed to describe the most interesting American species, commencing with

Section I. DESMIDIACEA.

Desmidium. *Free, carapace simple, urceolate, trilateral, often catenate.* Mandl and Ehrenberg, l. c. p. 244.)

Desmidium schwartzii, Agardh. (Pl. 21, fig. 1.) Corpuscles smooth, quadrangular on three sides, slightly emarginate, triangular on the other two sides, end obtuse, ovarium green, $\frac{1}{92}$ to $\frac{1}{96}$ of Paris line.

The corpuscles of this species are united together by their triangular faces, so as to produce long triangular (often twisted) filaments, which are of a beautiful green color, and exceedingly lubricous. Each filament is enveloped in a very transparent gelatinous matter, which is not visible on the dead specimens. The filaments often occur together in great quantities, and form a stratum in the water which is not distinguishable from a mass of some species of Zygnema, with which remarkable genus of Algæ this presents many points of resemblance. Allusion is made by several writers* to a "curious pinnatifid appearance" which this species presents "before the ultimate separation of the joints." I have not seen the filaments in this state, nor have I met with any detailed account of this change in the few works which I have been able to consult.

This species is extensively diffused in Europe, and appears to be equally so in this country. I have met with it from Rhode-Island to Ouisconsin, and south to Virginia; it occurs at West-Point in great abundance in ditches and peat bogs, where I have found it most abundant in early spring. I believe Desmidium cylindricum of Greville to be merely a *state* of this species.

Desmidium hexaceros, Ehrenberg. (Compare figs. 2 and 3, Pl. 21.) Corpuscles binary, trilateral, the points drawn out to three horns and truncate at the extremity, $\frac{1}{48}$ of line.

Desmidium aculeatum, Ehr. (Compare figs. 4, 5, and 6, Pl. 21.) Corpuscles spiny trilateral, the points drawn out to three truncate horns, often terminating in three spines.

I copy Ehrenberg's description of the two last species, that they may be compared with the figures referred to above, which represent various binary triangular bodies, some of which agree pretty well with the above characters. They, however, are so unlike D. schwartzii, and present so many points of resemblance to Euastrum, that I shall describe them as species of that genus.

Staurastrum. *Free, a simple univalve quadrangular carapace.*

Staurastrum paradoxum. Corpuscles rough, single or binary, four setaceous horns in form of a cross. Micrasterias staurastrum, M. tetracera, didicera, tricera. (Kuetzing, Linnæa, Vol. 8, p. 509, Pl. 20, figs. 83, 84 and 85.)

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* See Agardh, Systema Algarum, p. 15; and Greville in British Flora, Vol. 5, p. 402.

S. paradoxum, Meyen. (Nov. Act. Nat. Cur. Vol. 16, p. 777, Pl. 43.)

"Formed principally of two cells united end to end, and each terminated by cross-shaped prolongations, on which are perceived vestiges of articulation." (See Ferussac's Bulletin, June, 1830.

I am not sure that I have yet met with this species in America; I have, however, often seen the binary bodies represented by figs. 3 and 4, pl. 1, having four arms instead of the three represented in our drawing. In the four-armed state they agree closely with the above characters of *S. paradoxum*, as well as with Kützing's figure 83.

PENTASTERIAS. *Free, a simple univalve pentagonal carapace.*

Pentasterias margaritifera. Surface granulated, rays thick and obtuse. (Mandl and Ehrenberg, l. c. Pl. 8, fig. 46.)

I am unacquainted with this genus, unless it is founded on five-rayed bodies resembling figure 7, which are only varieties of figures 3 and 4; the number of arms being, as I have repeatedly seen, liable to much variation.

TESSARARTHRA. *Free, a simple carapace, univalve, globular, smooth, forming chains of four or more individuals by spontaneous division.*

Tessararthra moniliformis. Corpuscles green, two or four united in a right line. (M. and E., l. c. Pl. 8, fig. 47.)

I have not noticed this genus in America.

SPHÆRASTRUM. *Free, a simple carapace, univalve, smooth, inflated, forming groups of various forms by imperfect spontaneous division.*

I have not yet detected any specimens of this genus.

XANTHIDIUM. *Free, a simple carapace, univalve, globular, bristling with points or setæ, isolated, binary or quaternary, (catenate?)*

This genus is very interesting from the fact that bodies, almost identical in form with the living species, occur abundantly, preserved in the fossil state in flint. Drawings of several fossil species may be seen in the Annals of Natural History, Pl. 9, accompanying an interesting paper on the Organic Remains in the Flint or Chalk, by the Rev. J. B. Reade. The directions given for finding these bodies in flint, are "to chip off thin fragments which may be attached by means of canada balsam to slips of glass, and then coated on the outer surface with hard spirit varnish. A hundred specimens may be thus cut, polished and mounted for the microscope without trouble and expense, and in less time than an expert lapidary could prepare a single slice with the diamond mill and polishing tool." Many of the common gun flints contain these bodies. I am indebted to E. J. Quekett, Esq. of London, for very fine specimens of fossil Xanthidia; among them is a slice of flint prepared by a lapidary, which contains in a space of less than a square inch, as many as eight or ten very perfect Xanthidia, a scale of a fish, and other organic bodies.

There has been much discussion as to the real nature of the bodies in flint, which so closely resemble the recent Xanthidia; Turpin mistook them for eggs of Cristatella, to which, however, they have but little resemblance. Ehrenberg gives figures in his small treatise, "Die

Fossilen Infusorien und die Lebendige Dammerde," Pl. 21, figs. 2, 12 to 17, which show the closest resemblance between the recent and the fossil species. It is remarkable, however, that the recent species are inhabitants of fresh water, while flint is undoubtedly of marine origin. I have not seen distinct motion in any of our species.

Xanthidium? ramosum. Corpuscles globular, separate or binary, spines scattered, terminated in three or more points, $\frac{1}{96}$ to $\frac{1}{24}$ line. Fossil in gun flints.

Xanthidium ———. (Fig. 15, Pl. 21.) Binary, each portion having numerous rather long arms terminating in three diverging points.

This very beautiful American species is, when living, of a fine green color. Its carapace is hard and apparently siliceous, as it retains its form in spite of the action of fire and acids. Every living specimen of this species which I have seen, has been composed of two symmetrical portions, as shown in the figure. These bodies, when in the position shown in the figure, have much resemblance to Ehrenberg's drawings illustrating the spontaneous division of some of the species. When thrown into other positions, so that the line of union of the two portions is not seen, it may easily be mistaken for a simple spherical body bristling with arms. The two portions often separate after death, and may then be mistaken for individuals resulting from spontaneous division; but by throwing them into various positions by means of a compressor, the orifice corresponding to the line of separation of the two original parts may always be seen. The same remark will apply to the next species also.

It occurs not unfrequently in a subalpine pond a few miles from West-Point, and at Salem, Mass.; and it is also occasionally found in ditches, in peat bogs, etc.

Xanthidium ———. (Fig. 16, *a*, *b*, Pl. 21.) Binary; each portion somewhat triangular, and terminating at each angle in three short diverging arms, each having three small diverging points.

The smaller size and triangular form of these bodies, make me think them of a different species from the preceding. I have not seen any intermediate forms, although they occur together in about equal abundance at the above mentioned locality.

I must here remark that a transition from Xanthidium to Euastrum appears quite evident, through the binary triangular bodies, often having projecting arms, represented in figures 2, 3, 4, 9 and 8, Pl. 21.

ARTHRODESMUS. *Free, carapace simple, univalve, compressed in the form of a plate or a compressed band, articulated by spontaneous division.*

Arthrodesmus quadricaudatus. (Fig. 17, Pl. 21.) Corpuscles oblong, straight; chain or polypidom of four to eight individuals formed by imperfect spontaneous division; four horns, (the middle corpuscles rounded at the ends, the others with a horn at each end.) Size of corpuscles $\frac{1}{182}$ to $\frac{1}{96}$ line; chains $\frac{1}{48}$ line. *Scenedesmus magnus,* Meyen.

This species, as it occurs in this country, is composed of from four to eight green elliptical corpuscles arranged in a thread or chain, usually having horns only on the two extreme corpuscles, but not unfrequently similar projections may be seen on the middle ones also. Meyen, who considers this as a plant, states that in spring it contains starch globules.* It is exten

* MEYEN, Pflanzen Physiologie, Vol. 3, p. 437.

sively diffused, both in Europe and in this country: I have noticed it as far west as Ouiscon sin, and south to Virginia. It is abundant in ponds near West-Point, N. Y.

Arthrodesmus culus. (Fig. 18, *a*, *b*, Pl. 21.) Corpuscles green, oblong, alternating in a right line, by spontaneous division.

The small green bodies represented in our Fig. 18, occur in the well at Fort Putnam, West-Point. They appear to belong to this species.

ODONTELLA. *Free, carapace simple, univalve, compressed, form of flattened articulated ribbands, often pierced, produced by imperfect spontaneous division, articulations united by small projections.*

I have not satisfactorily determined any American species of this genus, although I have occasionally seen small filaments which agreed tolerably well with the generic character.

MICRASTERIAS. *Free, carapace simple, univalve, compressed; groups of a number of individuals in form of a flattened star, produced by imperfect spontaneous division.*

This is a very beautiful genus, its species presenting elegant star-like arrangements of green corpuscles, some of which closely resemble in form the stars and badges of honor worn in Europe.

There appears to me to be much confusion in the specific characters, arising from the circumstance that the number of corpuscles in the different rows has been made a character of specific importance. From what I have seen of the species, I am satisfied that the number of corpuscles in a star is liable to great variation in the same species. Perhaps the form of the corpuscles would prove a more certain character.

Micrasterias tetras. (Fig. 19, Pl. 21.) Four corpuscles united in form of star, the edge slightly notched.

This is a very minute species, which occurs in ponds near West-Point. I have also noticed it in Virginia.

Micrasterias boryana. (Fig. 20, Pl. 21.) Ten corpuscles in the exterior circle, five in the interior, and one in the centre, edge acutely dentate. Corpuscles $\frac{1}{80}$ to $\frac{1}{100}$ of line.

It happens accidentally that our figure represents an individual having just the number of corpuscles above described. I am satisfied, however, from frequent observation, that the same species sometimes has a much greater number of corpuscles, certainly another row of fifteen is often developed. It then agrees with M. tricyclia of Ehrenberg. It is a very beautiful object for the microscope. I have found it in New-York, Virginia, and in Ouisconsin.

Micrasterias ———. (Fig. 21, Pl. 21.) Corpuscles very numerous, forming large imperforate plates of a circular or elliptical form; exterior corpuscles deeply emarginate, each having two projecting points.

This large and very beautiful species is not uncommon in ponds near West-Point.

EUASTRUM. *Free, carapace simple, univalve, compressed, binary, sometimes quaternary, having the form of a two-lobed disc or lamina, often dentate.*

The elegant forms and emerald green color of the species of this genus render them exceedingly fine objects for the microscope. The forms, as usually seen, appear tabular; but when thrown on their sides by means of a compressor, they show considerable thickness.

I have noticed in several species, groups of molecules moving actively, precisely like those seen in Closterium. Indeed this genus is most closely allied to Closterium, and some forms occur which show a complete transition from one genus to the other. (See remarks under the head *Closterium*.)

Capt. Carmichael, with his usual acuteness, detected their animal nature. He remarks of two of the species, "these are animals instead of plants, if the faculty of locomotion will entitle them to that rank." (See Hooker's British Flora, Vol. 5, p. 398.) I have frequently noticed the motion of several species; it is quite as distinct as in Closterium.

Euastrum rota, Ehr. (Fig. 22. Pl. 21.) Body binary, lenticular, discoid, smooth, the edges dentate or spiny, $\frac{1}{24}$ to $\frac{1}{10}$ line. *Echinella rotata?* Greville.

The species represented in our figure appears to be the *E. rota* of Ehrenberg, and agrees pretty well with the account given by Greville of his *Echinella rotata*, which he describes as having the "frond plane, circular, divided by a line passing through the centre, each portion composed of radiating segments cleft nearly to the central line." (See Brit. Flora, p. 398.) Having seen no figures of the European species, I cannot be sure of their identity with ours.

The species represented in Fig. 22, is quite common in the United States. I have seen it in Rhode-Island, New-York, Virginia, and Ouisconsin; I have generally found it scattered among confervæ, but I once in early spring found many hundreds of them collected together on the bottom of a very small pool of water in a sphagnous bog. Some variety occurs in the outline; thus the two large central portions of each half are often perfectly symmetrical, and not unfrequently dentate near the ends. I have seen specimens twice the size of the one represented.

Euastrum crux-melitensis. (Fig. 23, Pl. 21.) Body binary, lenticular, discoid, smooth, the edges deeply divided into six dentate and spiny rays.

I copy this description, that it may be compared with Fig. 23, Pl. 21, which represents a very beautiful form which I have found in various situations near West-Point, and also at Staten Island. I have seen it move distinctly.

Euastrum ———. (Fig. 24, Pl. 21.) This is possibly only a younger state of *E. rota*, (Fig. 22,) with which it occurs.

Euastrum ———. (Fig. 25, Pl. 1.) This very elegant form is somewhat rare. It occurs at West-Point with the preceding.

Euastrum ———. (Fig. 26 and Fig. 27, *a*, *b*, *c* and *d*, Pl. 21.) I suspect that the species represented in Figs. 26 and 27, is the same as the Echinella oblonga of Greville, which he describes as being "compressed, oblong crenato-pinnatifid, and lobed, divided transversely almost to the centre." (Brit. Flora, Vol. 5. p. 398.)

Fig. 27, *a* and *b*, shows two positions of the same individual; *c* and *d* shows small individuals, which are probably the young of this species. Fig. 26, although much more deeply

lobed than Fig. 27, is probably only an older state of the same. They occur at West-Point; also near Detroit, Michigan, and in Ouisconsin.

Euastrum ———. (Fig. 28, *a*, *b*.) This species is neither lobed nor undulate; but while the general outline is convex, a minutely serrated edge may be seen. When thrown on its side, (Fig. 27, *b*,) it presents an unusual thickness.

If this species is compared with Fig. 38, Pl. 21, the close relation existing between the genera *Closterium* and *Euastrum* will be manifest.

Euastrum ———. (Fig. 29, Pl. 21.) I suspect that the bodies represented in Fig. 29, belong to this genus. They consist usually of four somewhat elliptical green bodies placed parallel to each other, and united laterally, as seen in the figure. Each elliptical portion is bidentate at the ends. I have met with specimens in which eight such corpuscles were united, producing such an appearance as would be given if a figure like that shown in Fig. 29, had a similar one added immediately below it.

If this is a species of Euastrum, perhaps it may be thus characterized: Euastrum ——. Binary (or sometimes quaternary); each corpuscle divided by deep lateral sinuses into two transverse somewhat elliptical bidentate portions, the middle portions longest. Occurs in ponds near West-Point.

Euastrum margaritiferum, Ehr. (Fig. 8, *a*, *b*, Pl. 1.) Body binary, elliptical, each part semi-orbicular with the margin entire, $\frac{1}{120}$ to $\frac{1}{24}$ line. *Heterocarpella tetrophthalma*, Ktz. (Linn. 1833, Pl. 19, Fig. 87.)

Our species (Fig. 8) agrees pretty well with the above description, and with Kützing's figure. A figure given by Meyen in his Pflanzen Physiologie, Vol. 3, Pl. 10, Fig. 31, apparently belongs to this species also.

The surface has a great number of minute hemispherical projections, disposed in a quincuncial order. It is possible that the pearl-like appearance of these projections, when seen on the empty carapace, may have suggested the specific name. I have seen this species move quite distinctly; and have also seen in it, (as well as other species of Euastrum,) groups of moving molecules as in Closterium, sometimes indeed the whole cavity is filled with such particles. Meyen states that the species he represents (l. c. Fig. 31, Pl. 10) contains globules of starch.

This species is very common in the neighborhood of West-Point. I once found, in the spring of the year, in a small pool caused by the melting of the snow in a peat meadow, a large cloud-like mass in the water, which, when touched, broke to pieces and became diffused through the water. On examination, it proved to be wholly made up of this species. I have found it in Rhode-Island, New-York, Ouisconsin, and Virginia.

Euastrum ———. (Fig. 9, Pl. 21.) Binary, triangular, angles rounded, each corpuscle having several rows of minute points. Hab. West-Point.

Euastrum ———. (Fig. 10, Pl. 21.) Binary, elliptical, each corpuscle having three pairs of long subulate spines. Hab. West-Point. I have met with individuals having the spines developed on only one side.

Euastrum ———. (Fig. 13, Pl. 21.) Binary, corpuscles cordate at base, each having six pairs of short spines.

This is a very pretty species, which occurs at West-Point. The figure shows the position of two groups of active molecules.

Arthrodesmus convergens. (Figs. 11 and 12, Pl. 21.) Binary, each corpuscle elliptical, and terminating at each extremity in a single spine. Hab. West-Point.

Euastrum ———. (Figs. 2, 3, 4, 5, 6, and 7, Pl. 21.) Binary, (sometimes quaternary,) generally triangular, and terminating in three long arms, each of which ends in three minute spines. Hab. West-Point.

The number of arms is usually three; but I have met with specimens in which one corpuscle had three and the other four arms, others in which both had four, and others again in which both had five arms.

It appears to me that the five-armed variety may have given rise to the genus Pentasterias, and the four-armed ones are possibly the same as Staurastrum. This, however, is only a conjecture, hazarded without having seen authentic specimens or good figures of those genera. The structure of the arms is exactly as in the Xanthidium, (Fig. 15, Pl. 21,) and there is indeed an evident relation between the genera.

The reader is requested to compare some of the figures last referred to, with the descriptions of *Desmidium hexaceros* and *D. aculeatum.*

Euastrum ———. (Fig. 14, Pl. 21.) Binary, corpuscles triangular, each angle terminating in a sharp spine. Hab. West-Point.

I have seen several other species of Euastrum, but the number figured is sufficient to give an idea of the variety and beauty of the forms in this interesting genus.

Closterium. (See Figs. 30 to 38, Pl. 21.) Ehrenberg makes of this genus a distinct family of Infusoria, which he calls the Closterina, and characterizes thus: ***Polygastric** (distinctly or probably) **without alimentary canal, without appendices; polypidoms having the form of a wand** ("**baguette**"), **thread or spindle, by spontaneous division; papillæ fixed and movable in the opening of the carapace.***

I have before stated that I consider the genus Closterium most closely related to Euastrum, and therefore with the Desmidiacea generally. This relation to Euastrum is manifest in their apparent identity in internal structure, the chief difference between them is only in the external forms; and even in them, we find there is a perfect transition from the highly lobed and tabular forms of some species of Euastrum, to the entire elongated and fusiform species of Closterium. It is therefore without hesitation that I place Closterium, (as indeed most writers do,) among the Desmidiacea.

There has been much discussion of the question, whether the Closteria are plants or animals; and as this inquiry is one of general interest, the decision of which will affect the position of all the family Bacillaria, I may be excused for giving at some length an account of the present state of the question. Ehrenberg gives the following reasons for believing the Closteria to be *animals:* 1. Their voluntary motion; 2. Their terminal openings; 3. The incessantly moving organs placed against the openings, and sometimes projecting; 4. Their spontaneous lateral division.

Morren, is his celebrated memoir "Sur les Closteriées," (some notice of which may be found in Silliman's Journal, Vol. 35, p. 122,) supports the view that the Closteria are *plants.*

Meyen, in his report on Vegetable Physiology, for 1837, (p. 54 of Francis's translation,) and also in his Pflanzen Physiologie, Vol. 3, p. 437, has brought forward the fact of the presence of starch in the Closteria, as conclusive evidence of their being plants. He states, that the large and small globules in these bodies "at certain times, and particularly in spring, "are almost wholly composed of starch." He adds that in the month of May, he had observed "many specimens of Closterium in which the whole interior substance was granulated, and all "the grains gave with iodine a beautiful blue color, as is the case with starch, which is not "an animal product."

In the Annals of Natural History for August, 1840, (No. 33, p. 415,) is given a notice of a paper read by Mr. Dalrymple before the Microscopical Society of London. As this paper gives a good idea of the present state of the discussion concerning the nature of the Closteria, I believe that no apology is necessary for taking from it the following extract, especially as my own observations enable me to confirm some of the statements and to correct others.

The author, after detailing the history of Closterium, from its discovery by Corte in 1774, down to the present time, entered into a detail of its appearance and general structure: He describes it as consisting of a green gelatinous and granular body, invested by a highly elastic and contractile membrane, which is attached by variable points to a hard siliceous shell, which was afterwards stated by Mr. C. Varley to resist even the action of boiling nitric acid. The form of Closterium is spindle-shaped or crescentic; the shell consisting of two horns, tapering off more or less to the extremities, and united at the central transverse line, constituting a perfectly symmetrical exterior. At the extremity of each horn is an opening in the shell, which, however, is closed within by the membranous envelope, wanting however in some specimens. Within the shell and at the extremity of the green body, is a transparent chamber containing a variable number of active molecules, measuring from the 20,000th to the 40,000th of an inch; these molecules or transparent spheroids occasionally escape from this chamber, and circulate vaguely and irregularly between the periphery of the gelatinous body and the shell; further, the parietes of this chamber have a contractile power. The author denied the existence of any papillæ or proboscides at this part, as well as the supposition of Ehrenberg that these moving molecules constitute the basis of such papillæ. He also denied the statement of the same distinguished observer, that if coloring matter was mixed with the water in which the Closterium resides, any motion was communicated to the particles of such coloring matter by the supposed papillæ, or by the active molecules within the terminal cells. A circulation of the fluids within the shell was observed, independent of the vague movements of the active molecules; this was regular, passing in two opposite currents, one along the side of the shell, and the other along the periphery of the gelatinous body. When the shell and body of the Closterium was broken by pressure, the green gelatinous matter was forcibly ejected by the contraction of the membranous envelope.

The action of iodine upon the specimens was very remarkable: 1st, it did not, as reported by Meyen, stain the green body violet or purple, but orange-brown; 2d, it produced violent contraction of the investing membrane of the body, whereby the green matter was often forcibly expelled from the shell at the transverse division; 3d, it instantly annihilated the motion of the molecules in the terminal sacs, and the sacs themselves became so distended with fluid as to burst and allow the molecules to escape.

The mode of reproduction was stated to take place, 1st, by spontaneous division; 2d, by ova; 3d, by interbudding, or the conjugation of two Closteria.

The author, after balancing the arguments of the two theories respecting the classification of this body, gave as his reasons for retaining them on the side of the animal kingdom, the following summary:

1st. That while Closterium has a circulation of molecules greatly resembling that of plants, it has also a definite organ, unknown in the vegetable world, in which the active molecules appear to enjoy an independent motion, and the parietes of which appear capable of contracting upon its contents.

2d. That the green gelatinous body is contained in a membranous envelope, which, while it is elastic, contracts also upon the action of certain reagents whose effects cannot be considered purely chemical.

3d. The comparison of the supposed ova with cytoblasts and cells of plants, precludes the possibility of our considering them as the latter; while the appearance of a vitelline nucleus, transparent but molecular fluid, a chorion or shell, determines them as animal ova. It was shown to be impossible that these eggs had been deposited in the empty shell by other infusoria, or that they were the produce of some entozoon.

4th. That while it was impossible to determine whether the vague motions of Closterium were voluntary or not, yet the idea the author had formed of a suctorial apparatus, forbade his classing them with plants.

Lastly, in no instance had the action of iodine produced its ordinary effects upon starch or vegetable matter, by coloring it violet or blue, although Meyen asserts it did in his trials.

The author, therefore, concluded that *Closterium* must still be retained as an infusory animal, although it is more than doubtful whether it ought to rank with the polygastric families.

Upon the above statements of Mr. Dalrymple, I venture to offer the following remarks.

1. *As to the siliceous nature of the carapace:* Ehrenberg expressly states, (l. c. p. 446,) that "the carapace can be burned and completely volatilized." This statement of Ehrenberg, together with the undoubted flexibility of the covering of many of the Closteria, which I have often noticed as wholly unlike the brittle siliceous coverings of the Naviculæ, and the fact that I have never found their coverings among the fossil Naviculæ, although the living species of each genus occur abundantly together, all induce me to think the carapace of Closterium can scarely be siliceous.

2. *Motions apparently voluntary.* These are easily seen: I have often been unable to sketch the form of a specimen by means of the camera lucida, as the body was constantly changing its position, and this too when certainly undisturbed by the motion of other animalcules or any extraneous cause. Their power of locomotion may also be rendered apparent thus: If a portion of mud covered with Closteria is placed in a glass of water, exposed to light, and the Closteria are then buried in the mud, they will soon work their way to the surface, covering it again with a green stratum, which may be buried over and over again, with the same results.

3. *Presence of moving molecules in distinct cavities.* These are easily seen; generally there is one such cavity in each extremity, as indicated in most of our figures of Closterium, (see Figs. 30 to 38, Pl. 21,) but sometimes there are many such cavities; at other times almost the whole interior appears filled with active molecules, as has already been stated (p. 15) is sometimes the case with Euastrum. In specimens where the cavities at the ends were very distinct, and which also showed very distinctly the circulation referred to by Mr. Dalrymple, I noticed that the form of the cavity containing the active molecules was constantly changing,

being sometimes globular, then elongating to the left or right, and then becoming globular again, in a rapid but very irregular manner.

4. *Presence of distinct circulation.* This was noticed many years ago by Gruthuisen. The account by Mr. Dalrymple, given in the above extract, agrees exactly with what I have seen in several species. The currents are very distinct; so much so, in fact, that they attracted my attention before I was aware that they had been noticed by others.

5. *Action of iodine.* I cannot otherwise account for Mr. Dalrymple's statement that iodine "in no instance produced in the Closteria the violet or blue color indicating starch," than by supposing that the specimens he examined were not in the proper state to exhibit it. Meyen expressly states, that it is "at certain times, particularly in spring," that the starch may be detected.

I am able by conclusive experiments to confirm Meyen's statements as to the presence of starch in these bodies. In specimens gathered in November, many of which I have still by me in a living state, I find no difficulty in producing the blue or purple color with tincture of iodine. Sometimes, however, the specimen becomes so opaque by the action of this reägent, that the purple color of the granules can only be detected after crushing the specimen by means of the compressor. The characteristic color of iodide of starch is then shown most distinctly. I have repeatedly treated in this way the large species, C. trabecula (Fig. 32, Pl. 21) as well as others, and have uniformly found that a portion of the interior takes the blue or purple color.

I cannot, however, consider the presence of starch in these bodies as conclusive evidence that they are plants. Is it not possible that they are animals which feed, wholly or in part, on amylaceous matter extracted from the aquatic plants among which they live? If so, the detection of starch in their stomachs is not surprising.

6. *Organs of motion and moving papillæ.* These I have not yet seen, but do not feel authorized to deny their existence, as I am well aware that my microscope,* although a very good one, is probably inferior to the one used by Ehrenberg. It shows the lines on the scales of Podura as well as I have been able to see them by any instruments in this country; yet I have not sufficient confidence in its power, or my skill in using it, to contradict the statements of results obtained by so distinguished an observer as Ehrenberg, in using the best instruments of Europe. I can vouch very positively for what I have seen, but will not pretend that more may not be seen by others.

I will now proceed to describe briefly some of the most interesting American species of Closterium, giving in connection with each the characters of the European species which appears to correspond to our own, as far as I can determine by the brief accounts, usually unaccompanied by figures, in the works to which I have access.

Closterium lunula. (Fig. 30, Pl. 21.) Semilunar or straight, diminishing gradually towards the rounded extremities; internal glands scattered, green granules arranged in several (10) threads, $\frac{1}{4}$ to $\frac{1}{12}$ line.

* Made by CHARLES CHEVALLIER, 130 Palais Royal, Paris.

Closterium moniliferum. Fig. 30, Pl. 21.) Semilunar, never straight, smooth, acute, and rounded at the ends, internal glands in the middle of the body arranged in a moniliform manner; green granules in several rows, of which the three middle ones are most distinct.

Specimens agreeing with the characters of each of the above species are common in this country. They do not, however, appear to be specifically distinct. They may be easily recognized by their smooth, green, crescent-like forms.

Closterium trabecula. (Fig. 32? Pl. 21.) Straight, cylindrical, contracted in the middle, smooth, the ends truncate, glands scattered or in several series, numerous obscure bands, $\frac{1}{12}$ to $\frac{1}{5}$ line.

I have seen no figure of this European species, but I nevertheless venture to refer to it, the fine species represented in figure 32. This is the largest Closterium which I have seen in the United States. It occurs at West-Point, at Staten Island, and in Virginia.

Its motions are quite distinct, the cavities containing moving particles very apparent, and what appear to be terminal openings may be easily seen. By the application of tincture of iodine, and then crushing the specimen under the compressor, starch globules may easily be detected. In crushing, the globules are often forced out at the terminal openings; and on relieving the pressure, are drawn back again. No rupture of a membrane at these points was perceived.

Closterium digitus. (Fig. 33? Pl. 21.) Straight, oval, cylindrical, four or five times longer than broad, smooth, the ends very much rounded, sometimes showing traces of a spontaneous triple division, longitudinal bands often denticulate, $\frac{1}{20}$ to $\frac{1}{10}$ line.

With this account may be compared Fig. 33, Pl. 21, which represents a species not uncommon at West-Point, and which I have also seen in Rhode-Island, Virginia, and Ouisconsin.

Its endochrome usually presents a central mass, from which several (ten) undulating ridges radiate to the carapace. It is a very elegant species.

Closterium lineatum. (Fig. 34? Pl. 21.) Very long, acute, slightly arcuate, cylindrical, filiform in the middle, the ends truncate, and very acute ("*tres amincis*"), ridges distinct in form of smooth lines; often thirty times longer than broad, $\frac{1}{18}$ to $\frac{1}{3}$ of a line.

Compare with this Fig. 34, Pl. 21, which represents a species quite common in ponds near West-Point, and which also occurs in Virginia. The figure represents only one half of the excessively elongated body. In the living specimens, the endochrome shows distinct ridges.

Closterium striolatum. (Fig. 35? Pl. 21.) Fusiform and arcuate, ends acute and truncate, ridges smooth, not deep, ten or twelves times longer than broad, $\frac{1}{10}$ line.

Compare Fig. 35, Pl. 21, which represents a common species.

Closterium rostratum, Ehr. Fusiform, slender, ends acute; setaceous horns about as long as the body, sometimes shorter. *C. acus*, Ktz. (Linn. 1833, fig. 81.)

I suspect the species shown in Fig. 36, Pl. 21, is a young state of this species. I found it among Lemna minor, on Staten Island, New York. Fig. 36, *a*, shows an individual produced by spontaneous division, one portion of which is still imperfectly developed.

Closterium tenue, Ktz. "Corpusculis minutis lineari-lanceolatis, viridi hyalinis, transverse fasciatis acutis." (See Linnæa, 1833, Pl. 8, fig. 78.)

I find no notice of this species in the extract from Ehrenberg's work, appended to Mandl's

work on the microscope; but as Kützing's fig. 78 resembles our species, (Fig. 37, Pl. 21,) I quote his description, that they may be compared.

Our species occurs in vast abundance on the muddy bottom of a brook which crosses the Canterbury road, a few miles from West-Point. It forms a mass of such extent, and of so bright a green color, that I at first mistook it for a layer of Oscillatoria.

There are very fine transverse lines, often visible on the carapace, and it often appears as if a portion of the shell between these lines (as at *a*, *b*, Fig. 37, Pl. 21) had been removed. Its motions are distinct and lively.

Closterium ———. (Fig. 38, Pl. 21.) Nearly cylindrical, contracted in the middle, ends obtuse, and in one position showing a re-entering fold of the carapace. Hab. ponds near West-Point. A similar fold in the carapace is visible in some species of Euastrum. (See Fig. 27, Pl. 21.)

MICROTHECA. *Free, carapace simple, univalve, compressed, separate, lamelliform.*

Microtheca octoceros. Carapace quadrangular, hyaline, four spines at each end, internal body golden yellow.

I am unacquainted with this genus.

NOTE. Having, in what precedes, completed a sketch of Desmidiacea, I propose to offer next some account of the other divisions of the Bacillaria, viz. the *Naviculacea*, the *Echinellea* and the *Lacernata*. Many of the species of these families have siliceous coverings, and are found in a fossil state. An account of our American species will, therefore, I trust, be found of some interest to American geologists, especially as the recent discovery by W. B. Rogers, of the vast infusorial stratum in the tertiary of Virginia,* cannot fail to attract new attention to these interesting bodies.†

SECTION II. NAVICULACEA.‡

As all the species referred to this section have siliceous coverings, they often occur in a fossil state, and hence their study is of peculiar interest to the geologist. In beauty of form and elegance of structure, they will bear comparison with almost any class of organized beings.§

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* See a notice of this discovery in the American Journal of Science, Vol. 31, p. 214.

† Since the preceding sketch was sent to press, I have seen in Schlechtendal's Linnæa for 1840, p. 201, a valuable memoir, by J. MENEGHINI, entitled *Synopsis Desmidiarum hujusque cognitarum.* It gives a very good account of the genera and species, with copious lists of synonims. I find my views as to the relations of several genera confirmed on perusal of this Synopsis, which I recommend to the attention of students of this curious class of bodies. J. W. B.

‡ These are *all* siliceous, and therefore often occur abundantly as fossils in peat bogs, and also in the silt and mud of rivers, ponds and marshes. J. W. B.

§ Since the second part of this article was ready for the press, I have received Pritchard's beautiful work entitled "History of Infusoria, living and fossil." I have gladly availed myself of the opportunity to introduce here many of the novel facts which it contains. Many of these facts will be given in the form of notes, as time does not now allow me to incorporate them in this sketch in any other form. J. W. B.

PYXIDICULA. *Free, carapace simple, bivalve (siliceous) separate, globular; (may be compared to a Gaillonella with perfect spontaneous division or without division.)*

Pyxidicula operculata. (Pl. 22, fig. 1 and 1 a.) Body spherical, divisible into two hemispheres, carapace hyaline, internal organs greenish yellow, $\frac{1}{120}$ to $\frac{1}{48}$ line.

I have seen hemispheres, probably derived from this species, among fossil infusoria from Manchester, Mass. &c.

Pyxidicula globata. This name has been given to globular bodies found in flint. Beautiful figures of them by Bauer, will be found in Pritchard's Hist. Infusoria, pl. 12, figs. 506 to 509. It is now suspected that these bodies are the gemmules of sponges, as the ramified tubes of sponge are often found preserved in the same pieces of flint.

Pyxidicula? (Pl. 22, fig. 2, a, b.) The spheroidal bodies represented by these figures, occur in the tertiary infusorial stratum discovered by Prof. W. B. Rogers in Virginia.* Of the real nature of these bodies I am quite uncertain; they agree however with Pyxidicula, in separating into two hemispherical portions. The surface is beautifully marked with rows of circular or hexagonal spots or cells, resembling those on the beautiful species of Coscinodiscus which accompany these bodies in the same deposit.

GAILLONELLA. *Free, carapace simple, bivalve (siliceous); form cylindrical, globular or discoid, producing chains [long articulated cylinders] by imperfect spontaneous division.*

Gaillonella moniliformis. (Pl. 2, fig. 3.) Corpuscles smooth, cylindrical, short, conical at the sides and truncate, form octangular [?] circular when seen endwise, ovaries green, $\frac{1}{72}$ line. *Ehr.*

Meloseira moniliformis, Ktz. (Linn., 1833, Pl. 17, fig. 71.) *M. nummuloides*, Grev. (in Brit. Flora, Vol. 5, p. 401.)

This very beautiful species grows only in salt or brackish water, and occurs in great abundance in various places in the United States, I first noticed it several years ago, among specimens of algæ from Providence, R. I. I subsequently found it almost covering the bottom and shores of Providence cove at low tide. I found it again in vast quantities, in salt ditches near the railroad at Stonington, Conn., where it formed large fleecy masses, sometimes of several feet in extent. Still more recently I have found it at Staten Island, and also, much to my surprise, sixty miles up the Hudson river near West-Point.†

The form is not strictly octangular, but at first appears so, in consequence of the two

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* For an account of this truly interesting discovery, see Report on Geology of Virginia for 1840. The infusorial strata of Virginia are of great interest from their vast extent, and from being the first infusorial deposits noticed in this country, of *a period anterior to the present epoch.* I am indebted to Prof. Rogers for specimens from various localities, and with his permission I include in this article figures drawn by myself of several of the interesting forms found in these beds.

† The Flora and Fauna of the Hudson river at West-Point would, in a fossil state, be rather puzzling to the geologist, on account of the singular mixture of marine and fluviatile species. While Vallisneria and Potamogeton grow in such vast quantities in many places as to prevent the passage of a boat, and the shore is covered with fluviatile shells, such as Planorbis, Physa, &c. in a living state; we yet find the above fresh-water plants entangled with bunches of marine algæ, such as Enteromorpha, Ectocarpus, &c., and often covered with marine parasitic zoophytes and marine infusoria (Achnanthes, Gaillonella, Echinella, Naunema, &c.; while the rocks below low water mark are covered with Balani and minute corallines, and the marine flora is represented by vast quantities of a very elegant Polysiphonia, nov. sp.?) abundance of Enteromorpha intestinalis, Ectocarpus siliculosus, and an elegant Alga, apparently identical with Delesseria leprieurii of Montagne, which was first detected on the shores of Cayenne. (See Annales des Sciences Naturelles, 2d series, Bot., tom. 13, p. 196, and pl. 5.

minute projections of the delicate transverse ridges seen near the ends of each of the two globules belonging to a joint. They do not change their form when heated to redness, or by action of hot hydrochloric acid. They fuse with effervescence with carbonate of potassa; and the fused mass, when treated with hydrochloric acid, gives silica in abundance. There can, then, be no doubt that the glass-like filaments of this species are siliceous. Our species agrees in all respects with authentic European specimens (in Herb. Tor.) collected by Hoffman Bang, at Hofmansgave.

Gaillonella aurichalcea. (Pl. 22, fig. 4, 4 a?) Corpuscles elongated, cylindrical, truncate, flattened smooth, contiguous; a simple or double pierced furrow in the middle of the body; ovaries greenish, becoming golden yellow when dry; $\frac{1}{192}$ line.

Conferva orichalcea. Ag. (Syst. Alg. p. 86.) *Meloseira orichalcea,* Ktz. (Linn., 1833, p. 72, 588, Pl. 17, fig. 68.)

Our species (Pl. 22, fig. 4, a, b,) agrees so closely with Kützing's figure 68, even in the branching character and occasional production of large globular joints (see (c) in fig. 4,) that I feel little hesitation in considering it as the *G. aurichalcea,* although I am unable to perceive the "sillon percé" alluded to by Ehrenberg in his specific character. This species might easily be mistaken for a Conferva. It often forms bluish green masses, of full a foot in extent, and while fresh it is quite as flexible as any Conferva; but on drying, it becomes of a light brassy yellow color, and is then excessively fragile. There is much variation in the diameter of the filaments, and in the relative length of the joints. The filaments which have the smallest diameter, have, generally, the longest joints. They retain their forms when heated to whiteness, and when treated with strong nitric acid. This species occurs in springs, rivulets, etc., and appears as common in this country as in Europe. In (Pl. 22, fig. 4, b,) is represented a species of Gaillonella apparently distinct from Figs. 4 and 4 a. It shows the pierced furrows, and agrees in most respects with the figure of *G. aurichalcea* given by Ehrenberg in his memoir entitled *Die Fossilen Infusorien und die Lebendige Dammerde,* Pl. 21, fig. 23. It is, possibly, only a state of our species above referred to. It occurs in ponds near West-Point.

Gaillonella distans. (Pl. 22, fig. 5.) Corpuscles cylindrical, short, truncate and flattened on the ends, smooth; with two pierced furrows, always separated in the middle; $\frac{1}{576}$ to $\frac{1}{72}$ line, usually $\frac{1}{288}$.

This species occurs in vast quantities in the fossil state in Europe. It constitutes a large portion of the slate of Bilin and Cassel, and of the "berghmehl" or "fossil farina" of various localities. It occurs in most of the specimens of American fossil infusoria, which I have seen. It is particularly abundant in the specimens from Manchester, Mass., which are chiefly composed of exceedingly minute frustules of this species. It forms here a true fossil farina, almost as light as flour, and *containing in a cubic inch many hundred millions of these minute siliceous shells.* It occurs in a living state at West-Point.

Gaillonella varians. (Pl. 22, fig. 6. a, b.) Corpuscles flat on each end; cylindrical surface smooth, ends with fine radiating lines; ovaries yellow or green; $\frac{1}{192}$ to $\frac{1}{40}$ line.

Our Fig. 6, represents a species which is not uncommon in ponds near West-Point. The discoid surfaces of the individuals show minute radiating lines quite distinctly.

Gaillonella sulcata. (Pl. 22, fig. 7, a, b?) I noticed fragments of this species two years ago in peat from a salt marsh near Stonington, and among marine algæ in the same vicinity. I had prepared a sketch and description of it for this article, before I heard of the discovery of the infusorial stratum of Virginia. I was, therefore, agreeably surprised to find, on inspecting specimens of the fossil infusoria from Richmond, Rappahannock cliff, &c., that this species was very abundant in them. A careful comparison of the recent specimens from Stonington, and the fossil specimens from the tertiary of Virginia, has left no doubt on my mind of their specific identity. The following is the account of the recent specimens, written several months before the reception of the Virginia fossils: They consist of frustules, each of which is divided by a transverse line; the cylindrical surface of each frustule has a great number of parallel lines in the direction of the axis, and the ends or flat surfaces show a rim having lines corresponding to those on the cylindrical surface; within this rim is a diaphragm having minute radiating lines. Chains of thirty or forty individuals are not unfrequent in the infusorial earth of Richmond, particularly in the upper part of the stratum. These are doubtless the "oblong cylinders" alluded to by Prof. W. B. Rogers in his Report on the Geological Survey of Virginia, p. 39. Ehrenberg gives the following description of *Gaillonella sulcata*, a fossil species occurring in the schist of Oran; from this description I suspect it to be closely allied to our species, and therefore copy its specific characters for the purpose of comparison.

"***Gaillonella sulcata.*** Corpuscles cylindrical, short, truncate at the two ends and flattened, furrowed across and in form of cells (sillonnes en travers et sous forme de cellules); $\frac{1}{96}$ to $\frac{1}{72}$ line." *.

Gaillonella? ———. (Pl. 22, fig. 8.) Corpuscles long, cylindrical; with two lines of constriction, adhering by alternate angles so as to form long zigzag chains, and occasionally auricled.

The curious bodies represented in Pl. 22, fig. 8, appear to partake of the characters of both Gaillonella and Bacillaria, showing the cylindrical corpuscles of the former, united by alternate angles as in many species of the latter. It is, perhaps, related to *Diatoma auritum* of Lyngbye, which is described as having the "joints quadrangular, rounded, with an auricle at each angle;" and of which Greville remarks, that the auricular appendages of the angles give to the frustules the appearance of "microscopic woolpacks." Having seen no figure or specimen of *D. auritum*, I cannot decide as to its identity with our species; I believe, however, that ours must be different, both from its abundance, and from the remark of Kützing Linnæa, 1833, p. 585) that *D. auritum* probably belongs to the Desmidiaceæ.

Our species consists of large cylindrical siliceous joints, usually adhering together by alternate angles in a zigzag manner. Most of the frustules show two lines of constriction, as shown in the figure. The connection of the frustules is by a very conspicuous, flexible hinge-like ligament, which often gives to the joints an auricled appearance, which makes the comparison of them to "microscopic woolpacks," or rather bales of cotton, not inappropriate.

The joints usually contain a yellow or ochraceous substance, arranged in a stellate manner,

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* In Pritchard's History of Infusoria, recent and fossil, I find a figure of *Gaillonella sulcata*, which leaves no doubt that our fossil specimens from Richmond, as well as our recent ones from Stonington, belong to this species. The living animals have also been detected at Cuxhaven, by Ehrenberg. See appendix to Pritchard's work, p. 434.

and not unfrequently this appears to be composed of minute globules, (ova?) as shown in the figure. This species occurs, in vast quantities, in the Hudson river, at West-Point. It may be found in some places at low tide, giving to the shores a ferruginous color in spaces even as much as a hundred square yards in extent.

Gaillonella ferruginea. Corpuscles very minute, convex on the ends, ferruginous, oval, smooth; having the form of articulated threads, often united, almost branching; $\frac{1}{3000}$ to $\frac{1}{1000}$ line.

Ehrenberg states with a mark of doubt, that it occurs in all ferruginous waters; fossil in bog iron ore; and in the yellow opal of Bilin. A copy of Ehrenberg's figure may be seen in Lyell's Elements of Geology, p. 39, (Am. Edit.) and in Pritchard's Hist. Inf. fig. 129–130. I have often seen in bogs and small streams, large quantities of a ferruginous colored flocculent matter which dispersed with great ease when touched, and in which I have sometimes been able to see, by means of the microscope, excessively minute filaments which were apparently moniliform. I believe these filaments to be the *G. ferruginea* of Ehrenberg, which is the same as the *Oscillatoria ochracea* of various algologists. The filaments are fragile and incombustible, and are said to be composed of silicate of iron. (See Pritchard's Hist. Inf. p. 199 and 200.)

ACTINOCYCLUS. *Free; carapace simple, bivalve, (siliceous); form cylindrical, (discoid) divided internally by several radiating partitions; spontaneous division imperfect in form of a chain.*

Ehrenberg mentions seven species, viz. A. ternarius, A. quaternarius, A. quinarius, A. senarius, A. septenarius, A. octonarius and A. denarius, distinguished respectively by the number of cells formed by the radiating partitions. Several species occur in the "schiste of Oran" in Africa, in a formation which M. Rozet considered as tertiary, but which Ehrenberg suspects is more nearly connected with the chalk.

It appears to me to be an interesting fact, that the remarkable marine infusorial deposit discovered by Prof. W. B. Rogers in the tertiary formation of Virginia, appears to agree with the infusorial conglomerate of Oran, in containing several species of Actinocyclus, together with *Gaillonella sulcata*, and beautiful punctate discs, which I suspect belong to the genus Coscinodiscus. I have seen no account of this last genus, but its name appears peculiarly appropriate to the sieve-like discs which form so large a portion of the infusorial stratum of Richmond, Va. Ehrenberg mentions *Coscinodiscus patina* as predominating in the deposits of Oran, Zante, Caltasinetta, &c. (See Weaver's View of Ehrenberg's Observations in Lond. and Ed. Phil. Journ. for May, 1841, p. 393.) In Figs. 9, 10 and 11, are represented several fossil species of Actinocyclus from Richmond, Va.; the same species also occur fossil in cliffs on the Rappahannock river. In Figs. 12, 13 and 14, are represented the discs which I believe to belong to the genus Coscinodiscus. When perfect, the form seems to be that of a torus, having the circular bases covered with hexagonal or circular spots, which present considerable variety in their size and arrangement in different specimens. The most usual disposition of the spots is in rows corresponding with the radii, as shown in the large specimen Fig. 14. In consequence of this arrangement they also form beautiful spiral rows in other directions, so that the curves present no inconsiderable resemblance to those often seen

on the backs of watches; at other times the spots are found to form three sets of lines, making angles of 60° and 120° with each other, as shown in Fig. 12; and on others the spots are disposed without much apparent regularity, frequently having a star-like figure in the centre. The spots are so small on some of the discs, as to be almost invisible even by the highest magnifying powers; on others, as in Fig. 14, they are quite large, and distinctly hexagonal. The largest discs have not always the largest spots. There are certainly several species of this genus in the infusorial stratum of Richmond, Va.; but as I have not seen Ehrenberg's account of the European species, I cannot venture to name our own.

Note. *October* 10*th*, 1841. Since the above was ready for the press, I have seen, in the appendix to Pritchard's History of Infusoria living and fossil, some interesting statements of recent discoveries by Ehrenberg, with reference to the genera of Actinocyclus and Coscinodiscus. It appears that these genera, which were first discovered in a fossil state in the schiste of Oran, Caltasinetta, Zante, &c., have also been recently found in sea water, and that many of the living species are identical with the fossil ones; indeed, Ehrenberg states that *Actinocyclus senarius*, *Coscinodiscus patina*, and *Gaillonella sulcata*, species now living, may be shown as the chief forms met with in the chalk marls of Sicily, and also that the species of the chalk formations are yet to be found as crowds of living creatures in the waters of our seas.

I select from the species of Coscinodiscus, described by Ehrenberg, the following, as apparently identical with American species from Richmond, Va. In connection with the description, I give a reference to figures drawn by me from fossil American species, long before Ehrenberg's characters for the species were received.

Coscinodiscus lineatus. (Pl. 2, fig. 12, a. b.) Carapace marked by small cells disposed in a series of parallel and transverse lines. Found fossil in the chalk marl of Caltasinetta, and in the live condition at Cuxhaven. The cells in this species form parallel lines in whatever direction they may be viewed. In large and well preserved fossil specimens, as many as twenty-five openings were seen near the circumference. Within the live forms, numerous yellow vesicles are sometimes seen, as in Gaillonella. Diameter of fossil, $\frac{1}{110}$th to $\frac{1}{40}$th; living $\frac{1}{110}$th to $\frac{1}{80}$th. Fossil at Richmond, Va.

Coscinodiscus radiatus. (Pl. 22, fig. 14.) Carapace large, marked with cells of moderate size, disposed in lines radiating from the centre. Towards the margin, the cells become smaller in size. Very abundant in fossil state at Oran; alive near Wismar and Cuxhaven; $\frac{1}{80}$th to $\frac{1}{20}$th. Fossil at Richmond, Va.

Coscinodiscus argus. (? Var. of *C. radiatus*.) Carapace with large cells at the centre, and smaller ones at the circumference, the order of the rays being often interrupted. Fossil at Oran and Caltasinetta in chalk marl, living in sea water at Cuxhaven. The cells of the discs from Oran vary very much in size. The ova are of a greenish color in the living forms, which are very rare. Diam. $\frac{1}{80}$th to $\frac{1}{20}$th. Fossil at Richmond, Va.

Coscinodiscus oculus-iridis. Carapace marked with rather large radiant cells, except near the centre and circumference, where they are smaller. Some of the larger cells in the centre form a sort of star. Fossil in the chalk marl of Greece; alive near Cuxhaven. Diameter, $\frac{1}{240}$. This large species is curiously marked, whilst under the microscope, with

colored rings, which are apparently caused by the peculiar arrangement of the cells. There are generally from five to nine large cells at the centre. Specimens are found in the infusorial stratum of Richmond, Va., which have the star-like centre, and probably belong to this species.

Coscinodiscus patina. (Pl. 2, fig. 13, a, b.) Carapace large; cells of moderate size, disposed in concentric circles. Cells smaller towards the circumference. Fossil in chalk marl of Zante; alive at Cuxhaven. The young and vigorous specimens of live individuals are completely filled with yellow granules, whilst the older ones have an irregular granulated mass within them. Diameter, $\frac{1}{800}$th to $\frac{1}{240}$th. Fossil at Richmond, Va. Our figure shows a small specimen.

Of the genus Actinocyclus, Ehrenberg describes several new species, which have been found fossil in the chalk marls of Oran, Caltasinetta, &c., and living in sea water at Cuxhaven, Christiana and Tjörn. Several of these species have no partitions, but have surfaces marked with minutely punctate rays. The great variety which occurs among the forms of Actinocyclus, found fossil at Richmond, leave no doubt in my mind, that all of Ehrenberg's species will be found among them. I also believe that I have seen a living species of this genus, or of Coscinodiscus, in the ooze of the Hudson river, near West-Point.

For Ehrenberg's character for the new species, see Pritchard's Hist. Inf., p. 428–429.

NAVICULA. *Free, separate or binary; carapace simple, bivalve or multivalve (siliceous), having six [?] openings; never united in form of a chain by perfect spontaneous division.*

On these characters as given by Ehrenberg for the genus Navicula, I would remark that there do not appear to be any true valves or parts capable of separation without fracture, although each species will usually break along certain lines or edges into a definite number of parts. I have not been able to satisfy myself of the existence of six openings in *N. viridis* (see remarks concerning that species); and with regard to the species ever forming chains, I can state that it is not rare to meet with four, sometimes even eight united laterally. I have even seen them thus united in the fossil state.

a. HAVING TRANSVERSE STRIÆ, (INTERNAL CELLS.) SUBGENUS SURIRELLA.

Navicula viridis. (Pl. 22, Fig. 16, a, b.) Striate, carapace straight, lateral faces truncate at the ends, ventral faces rounded at the ends, fifteen striæ (cells) in $\frac{1}{100}$th of a line. Length $\frac{1}{90}$ to $\frac{1}{6}$ line.

This beautiful species is one of the largest and most abundant, both in the recent and fossil state. It occurs all over Europe, and is equally diffused in this country. I have myself observed it in Maine, Massachusetts, New-York, Ouisconsin and Virginia. It is easily recognized by means of its large size and beautifully marked ventral faces. The striæ seen on these faces may correspond to internal cells, but I believe them to be linear openings in the carapace itself, as may easily be seen on the fragments of fossil specimens. There are three rounded spaces on each ventral face, which I think have been mistaken for openings, but which appear to me to be thicker portions of the carapace. One of these spaces is in the middle, and the other two at the extremities of the striated surfaces, and they are connected

by a very delicate double line (canal?) A similar structure is seen on several other species of Navicula, Cocconema and Gomphonema. The real orifices are shown at *c*, *c*, *c*, *c*, in our Fig. 16, *b*. Moving particles somewhat like those of Closterium may sometimes be seen near the extremities. In Fig. 17, a, b, Pl. 22, I have copied from Ehrenberg, (Die Fossilen Infusorien und die Lebendige Dammerde, Berlin, 1837, Pl. 1, fig. 19,) a sketch in which he represents the organs of motion, the stomach, etc. of this species. The reference letters having been omitted by the engraver of Ehrenberg's plate, I have been obliged to insert them according to what I believe was their intended position.

The following is a translation of Ehrenberg's explanation of this figure. (See Fig. 17, Pl. 22.)

"A living specimen of Navicula viridis, in which by the injection of indigo are distinctly to be seen: the stomach *v*, the two great spherical sexual glands *s s*, and the lamelliform extensions of the green ovarium, o′ mouth opening, o′ sexual opening? a, a, a, a, four movement openings, *p* the pediform organs of motion. The visible currents on the body, both when creeping and at rest, are denoted by arrows."

Navicula viridula. Carapace straight, lanceolate, linear, very slender, truncate at the ends, flattened on one side, lanceolate and obtuse on the other, 13 to 15 striæ in $\frac{1}{100}$ line, $\frac{1}{250}$ to $\frac{1}{24}$ line. ***Frustulia viridula***, Ktz. (Linn. 1833, Pl. 13, fig. 12.)

Ehrenberg mentions this as one of the species detected by him among fossil infusoria from West-Point. Kützing's figure does not allow me to determine with certainty, which of the various forms occurring at West-Point belongs to this species.

Navicula ———. (Pl. 22, fig. 18.) This figure represents a panduriform species, very much contracted in the middle. It occurs in peat from a salt marsh near Stonington, Conn.

Navicula ———. (Pl. 22, fig. 19.) This species occurs with the last, and is perhaps a state of it resulting from its complete spontaneous division into two individuals by the contraction at the middle.

Navicula ———. (Pl. 22, fig. 20.) This resembles the preceding very much, but is a fresh-water species, occurring in ponds near West-Point, also in streams in Virginia.

Navicula? striatula. (Pl. 22, fig. 21, *a*, *b*.) I refer to this genus, with much hesitation, the very elegant and interesting species shown by Fig. 21, *a*, *b*. It is easily known by a set of peculiar and beautiful undulating ridges, represented in the figure, and which give to the margin of the form a ruffled appearance, in whatever position they are observed. One of the faces (a) is lanceolate, the other (b) is somewhat wedgeform, with both ends obtusely truncate. The lanceolate face shows a set of fine lines apparently proceeding from the ridges above referred to, and reaching nearly to the middle line of the face. I have sometimes seen two individuals united laterally by their lanceolate faces, producing a very beautiful form. All the individuals which I have seen have been free, without pedicel, and when living, their spontaneous motions were very distinct. I have found it in a living state in fresh-water ponds and streams near West-Point; also in Mountain run, near Culpepper court-house, in Virginia; and I detected it in a fossil state among other fossil infusoria from Bridgewater, Mass. (See Figs. 6 and 7, Pl. 20, of Hitchcock's Final Report on Geology of Massachusetts.)

In Pritchard's History of Infusoria, I find two figures representing *N. striatula*, which leave no doubt that ours is the same species. (See Hist. Inf., Pl. 3, fig. 137, 138.) The

following interesting remarks with regard to the organs of locomotion in this genus, are also taken from this work.

"In the small pools left by ebb of the tide near Cuxhaven, Dr. Ehrenberg remarked numerous little bodies, apparently similar to *Navicula* (*Surirella*) *elegans* and *N. striatula;* but which, from their comparatively very great size and structure of lorica, were easily distinguishable from the latter upon closer examination. One of these ribbed glass-like creatures was, besides its size, remarkable for its great mobility; and Dr. E. was enabled to investigate its system of locomotion much more satisfactorily than he had hitherto done, in any of the genus. This organ he states was very different, both in form and size, to what he had before noticed in that genus. Instead of a snail-like expanding foot, long delicate threads projected where the ribs or transverse marks of the shell join the lateral portion of the ribless lorica, and which the creature voluntarily drew in or extended. An animalcule $\frac{1}{1\,8}$th of a line long, had twenty-four for every two plates, or ninety-six in the total; and anteriorly, at its broad frontal portion, four were visible. It is probable that this creature may form the type of a special group of the Bacillariæ."

Navicula ———. (Pl. 22, fig. 22.) This small species of Navicula with striate faces, is not uncommon in the infusorial stratum of Richmond, Va.

b. WITHOUT TRANSVERSE STRIÆ.

Navicula ———. (Pl. 22, fig. 23, a, b.) This species is distinguished by having two grooves which cross each other at right angles on the ventral face, presenting a cruciform appearance, and dividing this face into four equal portions, which are without striæ. It is a conspicuous species of many American specimens of fossil fresh-water infusoria, and is very common in the living state. I have found it in New-York, Ouisconsin and Virginia.

Navicula sigma. (Pl. 22, fig. 24, a, b.) Smooth, carapace lanceolate on the straight side.

Our figure represents a sigmoid species, found among marine algæ at Stonington, Conn. A somewhat larger sigmoid species occurs in the infusorial stratum of Richmond, Va.

Navicula? ———. (Pl. 22, fig. 25, a, b.) This very remarkable form I detected among fossil infusoria, from the infusorial stratum of Richmond, Va. It is lanceolate when seen on one side; on the other side it presents the curious outline shown in Fig. 6.

NOTE. This may possibly belong to Ehrenberg's new genus Zygoceros, which is described as having a compressed navicula-shaped carapace; each end provided with two perforated horns. (See Pritchard, l. c. p. 427.)

In addition to the American species of Navicula above described, Ehrenberg mentions the following as occurring in a fossil state at West-Point, viz: N. alata, *nov. sp.;* N. amphyoxys, and N. suecica. I am, however, ignorant of their specific characters. I have met with many species besides those referred to in the present memoir, but omit them, as my present object is to present only the most interesting forms.

EUNOTIA. *Free, single or binary; carapace simple, bivalve or multivalve (siliceous) prismatic; four openings on the same side, two at each end, ventral side flattened, back convex and often dentate, never catenate by perfect spontaneous division.*

Eunotia arcus. (Pl. 22, fig. 26, a, b.) Striate, carapace semi-lanceolate, elongated, two terminal knobs arcuate, 11 striæ in $\frac{1}{100}$ line.

Ehrenberg mentions *E. arcus* as occurring among fossil infusoria from West-Point. I presume that our figure, which represents a form very common both in the recent and fossil state in the United States, belongs to this species.

Eunotia diodon. (Pl. 22, fig. 29.) Striate, carapace elongated, ventral side flattened, slightly bidentate at the middle of the back, 19 striæ in $\frac{1}{100}$ line, $\frac{1}{40}$ to $\frac{1}{24}$ line.

Hab. West-Point, fide Ehrenberg. Probably the same as fig. 29, which is common both recent and fossil at West-Point, and elsewhere in the United States,

Eunotia tetraodon. (Pl. 22, fig. 31.) Striate, carapace semi-lunar, short, flattened or concave on the ventral side, four rounded teeth on the convex back, 23 striæ in $\frac{1}{100}$ line, $\frac{1}{90}$ to $\frac{1}{48}$ line.

Common among fossil infusoria from Manchester, Mass., and West-Point, N. Y. The living species occurs at West-Point.

Eunotia pentodon. (Pl. 22, fig. 32.) Striate, carapace semi-lunar, short, five teeth on the convex back, 23 striæ in $\frac{1}{100}$ line.

Fossil at Manchester, Mass. Living at West-Point.

Eunotia serra. (Pl. 22, fig. 33.) Striate, carapace linear, slightly curved, twelve to thirteen rounded teeth on the convex back, 19 striæ in $\frac{1}{100}$ line, $\frac{1}{36}$ to $\frac{1}{24}$ of a line.

Our figure is from specimens found fossil in Massachusetts. I have also received it from various other localities.

I strongly suspect that the number of the teeth on the back of the four last described species of Eunotia is liable to variation, and that the number of species has in consequence been made too great. (See remarks in Final Report on Geology of Massachusetts, Vol. II. p. 310, et seq.)

Eunotia ———. (Pl. 22, fig. 27, a, b.) This species was found in water from a brackish ditch in New-Jersey, which was sent to me for examination by Dr. Torrey. It is concave on one side, convex on the other, with a slightly elevated and widened portion in the middle. It is also minutely striate.

COCCONEIS. *Free, single, carapace simple, bivalve (siliceous), prismatic or hemispherical, a single opening in the middle of both sides of each carapace (?), never double or catenate by spontaneous division.*

Cocconeis? (Pl. 22, fig. 34.) Represents what I believe to be a species of Cocconeis. I found it adhering to a small marine Alga from the eastern shore of Florida.

Beautiful figures of *Cocconeis* (*Campylodiscus*) *clypeus*, drawn by F. Bauer, will be found in Pritchard's Hist. Inf., Pl. 12, fig. 516 – 518. I have received fine specimens of these elegant fossils from E. J. Quekett, Esq. of London.

BACILLARIA. *Free, (never fixed); carapace simple, bivalve or multivalve (siliceous), prismatic, forming chains or zigzag polypidoms by imperfect spontaneous division of the carapace and perfect division of the body.*

Bacillaria paradoxa. (Pl. 22, fig. 35.) *The standard bearer.* Striate, carapace linear, very slender, often fifteen times longer than broad, yellow, frustules very active, $\frac{1}{96}$ to $\frac{1}{240}$ line. Syn. *Vibrio paxillifer*, Mueller. (See Encyl. Meth. Pl. 3, fig. 16 to 20.)

I first detected this species in October, 1840, among algæ from the Hudson river, near West-Point. I am informed by Dr. P. B. Goddard of Philadelphia, that it also occurs in abundance near that city. It is a very interesting species, presenting by its curious motions and paradoxical appearance an object well calculated to astonish all who behold it. At one moment, the needle-shaped frustules lie side by side, forming a rectangular plate; suddenly, one of the frustules slides forwards a little ways, the next slides a little also, and so on through the whole number, each however retaining a contact through part of its length with the adjoining ones. By this united motion the parallelogram is changed into a long line; then some of the frustules slide together again, so that the form is then much like a standard. Similar motions are constantly going on, and with such rapidity that the eye can scarcely follow them. There are few more interesting objects for the microscope.

Several of the positions of these singular productions are well represented by Müller. (See Enc. Meth. Vers. Pl. fig. 16 – 20.) Müller found his specimens abundant on *Ulva latissima;* I found mine pretty common among Enteromorpha, Polysiphonia, Potamogeton, which grow together in brackish water on the flats in the Hudson river, near West-Point.

Bacillaria? tabellaris. (Pl. 22, fig. 36, *a*, *b*.) Smooth, carapace linear, narrow, swollen in the middle, dividing into quadrangular plates of variable length, ovary lobed and yellow, $\frac{1}{960}$ to $\frac{1}{840}$ line (width of filament.) Syn. *Diatoma flocculosum*, Kuetz. (Linn. 1833, Pl. 17, fig. 67.) *Diatoma flocculosum*, Greville, in Brit. Flora, Vol. V. p. 406.

This species is very common in all parts of the United States which I have visited. It is easily recognized by its zigzag chains, composed of plates (individuals) of various width, which have the middle and two outer edges considerably thickened, as is shown in the side view, fig. 36, *b*.

In fig. 37, *a*, *b*, is represented what I believe to be the full grown state of the species. It at first view appears very distinct from fig. 36; but on examination, we find the same thickening of the middle and ends, and similar transverse lines. The two varieties or states occur together; both are also found fossil. They are very abundant in ditches and ponds near West-Point.

Bacillaria ———. (Pl. 22, fig. 38.) This is a marine species, which I found at Stonington, Conn. and Staten Island, N. Y., adhering to filamentous algæ. It is distinguished by having on each half of its frustules two lines which commence near the centre, and run straight and parallel until they arrive near the extremities, when they suddenly become falcate for a short distance, and then resume their original directions. The curved portions of the lines have some resemblance to the upper portion of a pair of tongs. The position of these lines is very similar to those on *Bacillaria meneghinii.* (See Schlechtendal's Linnæa, 1840, Tab. IV. fig. 1.)

TESSELLA. *Free; carapace simple, bivalve or multivalve (siliceous), prismatic, compressed in form of plates; forming zigzag polypidoms by imperfect spontaneous division of the body, and perfect division of the carapace. The chains have spontaneous motion.*

Tessella catena. (Pl. 22, fig. 39?) Carapace lamelliform, often broader than long, 4–24 longitudinal series of transverse striæ, 10 striæ in $\frac{1}{100}$ line.

Fig. 39 is copied from a species, of which I found a few individuals adhering to a dried Alga from Stonington, Conn. It appears to belong to *T. catena.*

FRAGILLARIA. *Free, carapace simple, bivalve or multivalve (siliceous), prismatic; forming chains resembling fragile ribbons, resulting from the imperfect division of the carapace and body.*

Fragillaria pectinalis. (Pl. 22, fig. 40.) Striate corpuscles broad, 2 to 4 times longer than broad, swollen and lanceolate on the lateral side, ovary yellow, $\frac{1}{192}$ to $\frac{1}{36}$ line.

The flat ribbon-like filaments of this species are very common in ponds, and slow running streams near West-Point, and they often form masses as much as a square foot in extent. The filaments are of a yellowish green color, and resemble flat ribbons crossed by transverse parallel lines. Great variety occurs in the size and form of the frustules, but they are generally much longer than wide. Very minute striæ may often be distinctly seen on the edges of the frustules, as represented in our figure, but sometimes it requires a high magnifying power and skilful management of the light to render these apparent.

The masses composed of these filaments dry to a glistening silvery mass, which is exceedingly fragile, and which is unchanged by fire or nitric acid.

This species is not unfrequent in the fossil state, but the chains are then usually broken up.

Pl. 22, fig. 41, represents a variety (?) of this species with very narrow frustules, each of which, when living, was marked with two yellowish spots (ovaries?) Perhaps this is *F. bipunctata.* It occurs abundantly at Detroit, Mackinaw, and West-Point.

Fragillaria trionodis. Ehrenberg mentions this species as occurring in a fossil state at West-Point. I am ignorant of its characters, and may have confounded it with *F. pectinalis,* to which species all the varieties occurring at West-Point appear referable.

MERIDION. *Free, carapace simple, bivalve or multivalve (siliceous), prismatic, wedgeform; forming fragile spiral chains which often appear like complete circles, and which result from imperfect spontaneous division.*

Meridion vernale. (Pl. 22. fig. 42, a, b.) Corpuscles wedgeform, striate, anterior end truncate and dentate, polypidom spiral, often appearing perfectly circular, $\frac{1}{95}$ to $\frac{1}{20}$ line. *M. circulare,* Agardh. *M. circulare,* Kuetzing, (Linn. 1833, Pl. 15, fig. 37.)

This is one of the most beautiful of the fresh water infusoria, and excites great admiration in all who behold its elegant form and markings, under a good microscope. It occurs in immense quantities in the mountain brooks around West-Point, the bottoms of which are literally covered in the first warm days of spring, with a ferruginous colored mucous matter, about one quarter of an inch thick, which, on examination by the microscope, proves to be filled with millions and millions of these exquisitely beautiful siliceous bodies. Every submerged stone, twig, and spear of grass, is enveloped by them; and the waving plume-like appearance of a filamentous body covered in this way, is often very elegant.

The spiral or helicoidal form of the chains is not easily perceived, unless the chains are thrown on edge, (as in fig. 42, b.) This is easily effected with Chevalier's compressor.

Alcohol completely dissolves the endochrome of this species, and the solution, when evaporated, leaves a greenish resinous mass. The frustules, after the action of alcohol, are as colorless as glass, and resist the action of fire and nitric acid.

The infusoria are so minute, that many millions of their shells and coverings are contained in a cubic inch of the infusorial earth, which forms extensive deposits in many parts of our country, and particularly in the primary regions of New-England and New-York. By the silent, and until lately unnoticed operations of such minute animals, the foundations of new surfaces, capable of subsequent tillage, are laid. Daily additions are thus made to the habitable surface of the earth, and the stagnant ponds and marshes become verdant and beautiful meadows. These minute animals undoubtedly secrete the siliceous matter from the silex dissolved in the water in which they live, as we do the materials in our bony system from the food that we eat.

The primary rocks, by their gradual decomposition, yield silex in solution by the aid of potassa, which combines with it in the nascent state; and thus these animals are probably in part provided with the means of secreting it so as to form their coverings, and give rise to there being a greater proportion of this infusorial earth in such countries, than where the rocks are composed of the disintegrated and recomposed fragments of preëxisting ones; as we see in the case of lake marl, which abounds most in limestone regions, or where the springs or decomposing rocks furnish the greatest quantity of carbonate of lime in solution, from which the molluscous animals secrete it.

Lime, whence derived.

Several authors, among whom are Thomson, Macculloch, Bakewell and others, have revived the idea that lime has been formed from organic secretion, and that the vital powers have combined elements to form them. This idea is carried out by many to so great an extent, as to suppose the greater abundance of calcareous rocks in the more recent than in the older rocks, was caused by the quantity continually formed by succeeding races of animals for their own use, being greater than was necessary to supply the next succeeding race, so that a surplus was continually accumulating. There are no facts to justify such a theory, which can not be explained on other grounds, and a multitude of facts militate against it.

It is a matter of common notoriety, that shells do not abound in ponds or lakes where there are no limestone rocks, calcareous springs, or springs of hard water. Almost all soils contain a little carbonate or muriate of lime, some of which is carried by the surface and spring waters in a state of solution into the marshes, brooks and ponds. It there serves as a covering to the testacea, when secreted by them, as the animal system secretes the various substances necessary for itself from its food. But in soils that furnish little carbonate or muriate of lime, the testacea do not accumulate, because each succeeding race consumes the shells

of the preceding for its own covering and protection. Most observers are aware that in the primitive districts of the United States where there is no limestone, the testacea are exceedingly rare; but wherever limestone or limestone and springs abounds, they are numerous.

Testaceous animals are often seen on limestone rocks and pebbles, or on other shells both dead and alive, sucking off the carbonate of lime to serve their own purposes. The uniones are a good example of this fact; many of them are seen with a curved cavity, some with many on and near their beaks, which have been formed by taking a part of the superfluous covering from their fellows.

Where there are limestone springs, some of the lime is continually carried into the brooks and marshes; so that it is constantly accumulating, and forming sinter and tufa, encrusting the vegetable and animal substances; or deposited with the shells and other organic matters forming shell marl, for the future benefit of man.

Those charæ that secrete the greatest quantity of calcareous matter in their stems, are most abundant in the vicinity of limestone springs.

It is a well known fact, that if the common hen be shut up where she can have no access to the earth, so as to scratch up the gravel and select such particles as contain lime, and if she be not fed with something containing lime, she either ceases to lay, or else the eggs have too slight a covering to protect the contents.

Many birds eat chalk and sepia bone greedily during the breeding season. This is to supply lime for the shells of their eggs, and for the bony matter of their animal system. Tame birds are often fed with sepia bone. The object is that just mentioned, and not for sharpening their bills, as many suppose.

It has been argued by Bakewell and others, that the polypi which form the coral reefs could not procure such quantities of lime from sea water, which contains very little, in consequence of their not having the power of locomotion; and that consequently it must have been an organic product, combined by the vital powers from more simple elements. This conclusion is strengthened in his mind by the discovery of Sir Humphrey Davy, that the earths and fixed alkalies had metallic bases, and by the apparent metallization of ammonia when galvanized in contact with mercury. Now we know the ammonia to be composed of two gaseous bodies, nitrogen and hydrogen. He infers then by analogy that the other alkalies and earths were constituted of more simple elements than we were acquainted with, and that the animals had the power of combining these from their food for their uses.

The decomposition of ammonia to produce a metal, is a thing long since exploded. The whole superstructure built upon this foundation, of course, falls to the ground; and the formation of *lime* from more simple elements than we are acquainted with, by organic combination, as one of the columns of that structure, falls with it.

Besides the failing of this argument, Mr. Bakewell does not seem to have considered, that although the zoophytes have not the power of locomotion, and although sea water contains but little lime, yet the currents are continually supplying the animals with a fresh supply of water, from which constant secretion of the lime may result, upon the same principle as we

breathe the air of the atmosphere, and secrete the oxygen for purposes of the animal economy, or eat our food from which we secrete the solid materials of our osseous system.

We see no reason for supposing that the lime now on the surface, or in the crust of the earth, may not have existed as such, as well as silex, alumina and other mineral bodies, before the first organic beings. Most persons suppose, and there are reasons for the belief, that the arrangement of the original inorganic materials of our globe preceded the introduction of the first organic inhabitants.

We know that the sea contains lime, that rivers, springs and volcanoes are continually contributing fresh supplies from the interior of islands and continents, and from the bowels of the earth, and thus tending to remove the older limestones.

We see then that no argument can be sustained in favor of the organic origin, or the progressive increase of the absolute quantity of limestone, from the magnitude of coral reefs, or the greater proportion of limestone in the more modern formations.

ALLUVIONS FROM SOLUTION.

These alluvions are numerous, and some of them are of importance in consequence of their extent, and others from their economical applications, or the chemical or physical changes incident to their formation or deposition. They may be classed under the following heads, viz :

1. Calcareous tufa or sinter, stalactites, stalagmites, calcareous concretions, incrustations, and clay balls.
2. Sulphate of lime, alum, sulphate of alumina and iron.
3. Nitrates of lime and of potassa.
4. Sulphate of magnesia, and muriate of soda.
5. Springs (chalybeate, hepatic, acidulous, gaseous and thermal); common springs.
6. Caves, sink-holes, subterranean streams, and springs.
7. Sulphur, carburetted hydrogen and sulphuretted hydrogen.
8. Sulphate of iron.
9. Orpiment and arseniate of iron.
10. Bog ore and wad.
11. Carbonates of copper.
12. Alluvial sandstones and conglomerates.

1. Calcareous Alluvions.

Calcareous tufa is abundant in the limestone regions of the First district, and frequently contains shells of helices, the perfect impressions or moulds of the leaves of forest trees and other plants, the stems and roots of plants, or their moulds where they have decayed. It also frequently incrusts twigs and moss, which seem petrified; and in some instances it replaces

the woody fibre of plants as they decay, so as to represent the organic *structure*, although the organic *substance* has disappeared.

The calcareous matter is sometimes deposited so as to invest and coat over irregular surfaces of rocks, earth, or whatever it comes in contact with, like a coat of plaster; and all the successive layers deposited are superposed in parallel layers over the first one.

The imitative forms of these calcareous alluvions are very numerous; some are like hanging drapery and icicles, and called *stalactites*, which are formed in caves, or wherever water drips from particular lines or points, and containing mineral matter in solution which is more or less deposited from the dripping water; some are irregular, tuberculated masses, or like groups of warts or mushrooms; some are mammillary or botryoidal in form; and sometimes the deposition is porous and spongy in its texture, and is then called *tufa* and *sinter;* and sometimes like loose earth, and then called *tufaceous marl.* The stalagmites form on the floor of caverns or other places of deposition, instead of hanging from the roof like stalactites, and both are sometimes so pure and crystalline as to be strongly translucent. Those of Ball's cave, in Schoharie, are among the most beautiful I have ever seen; resembling in translucency, color and delicacy, the finest bleached wax or spermaceti. Mr. J. Bonny, and the Messrs. Gebhard, of Schoharie, have many fine specimens; and in the collection of John Gebhard senior, may be seen a stalagmite from that cave, of the weight of two hundred pounds or more, which excels any thing of the kind for its beauty that I have ever seen. Stalagmites are sometimes used for ornamental marbles; and those of Ball's cave, could they be procured of sufficient size, would be highly prized for this purpose.

Calcareous tufa, in an earthy form, occurs on the road from Schoharie to Cobleskill, a short distance up the hill from the Schoharie bridge. A limestone spring had its outlet at this place many years ago, and a large body of this tufa or tufaceous marl was deposited. The spring, or another similar in size, now flows from another place in the vicinity.

Another locality is near the sulphate of baryta locality in Carlisle, in Schoharie county, half a mile north of Grosvenorville, where a copious limestone spring flows from the junction of the water limestone series with underlying slate rock.

Another locality, and the most interesting one known in Schoharie county, is at Sharon springs. Here is a mass of tufa averaging two hundred yards in length, fifty yards in breadth and ten in thickness, probably containing at least one hundred thousand cubic yards of rock, formed entirely by deposition from the waters of these springs. In some parts of this mass, sulphate of lime and sulphur are found. The shells of helices are found rather abundantly in some parts of the mass, and the perfect impressions of the leaves of the beech, some species of oak, of the maple, the birch (white and black), and many other of our forest trees, can be easily procured. The tufa is a firm compact stone in many parts of this deposit; in others it is soft, spongy or slaty. Moss and twigs are incrusted in some localities on this deposit, and make beautiful specimens. The tufa is variously colored; white, brown, red, etc., according to the purity of the water, or the intermixture of organic or inorganic matter.

Many localities might be mentioned, where smaller deposits of tufa were observed in Schoharie county, but the above are the most important.

In Albany county, stalactites and stalagmites were observed in some parts of the caves in Bethlehem, near Clarksville. The stalagmites in some places formed thick masses, highly crystalline. Tufa was also observed near a copious limestone spring near Clarksville.*

In Greene county, tufa was seen near a limestone spring three miles west of Athens; also about three miles west of Coxsackie; also about three miles west of New-Baltimore; also at several localities by limestone springs along the base of the limestone cliff by the road-side, between Catskill and Saugerties.†

In Washington county, tufa occurs near Whitehall, as a deposit from springs.‡

In Ulster county, tufa was observed on the banks of Stony creek, on the land of David Schoonmaker, about two miles south of Rochester, at the base of a cliff of the water lime-stone series. It contained helices and impressions of leaves. It was white and porous, and specimens of incrusted moss were observed.

In Columbia county, tufa, enclosing helices and encrusting moss, occurs in several places around Becraft's mountain; but it is more easily found at the spring that supplies the city of Hudson with water.

The localities thus far mentioned, are all at or near the base of the Water-lime group of the Helderberg division of rocks. The waters that issue from this junction of the water lime-stones with the "Salt group," or with the rocks of the Hudson slate group, are all strongly impregnated with carbonate of lime, and in many places with several other mineral ingre-dients, giving rise to mineral springs. A large share of the sulphur springs of the First dis-trict have this geological situation.

In Saratoga county, tufa was observed on the banks of the Hudson between Glen's and Baker's falls. The most beautifully incrusted moss was obtained from this locality. It is said to abound at Saratoga.§

In Schenectady county, tufaceous marl in a loose form was observed a few miles above the city of Schenectady, near the left bank of the Mohawk. Tufa is also said to occur near the city.‖

These localities in Saratoga and Schenectady counties, are near the Trenton limestone.

Concreted carbonate of lime was seen in small quantity, at and near the "Spook hole," a cave near Barnegat in Dutchess county. Tufa is mentioned by Cleaveland (p. 175), near Rhinebeck.

Tufaceous marl occurs on the farm of Mr. Tilden in New-Lebanon, Columbia county. It is deposited from the water of a limestone spring. The deposit is abundant, and may be used as a marl.

Calcareous tufa is deposited in abundance from the thermal waters of the New-Lebanon springs.

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* Calcareous tufa is said to have been found at Albany, by Mr. J. Eights. (Webster's Catalogue of the Minerals of New-York, 1824, p. 5; and Robinson's Catalogue of Minerals, p. 114.)

† Robinson's Catalogue of Minerals, p. 116 – 120; and Silliman's Journal Vol. 3, p. 236.

‡ Robinson's Catalogue of Minerals, p. 158. Prof. Wells. § Ib. p. 150. ‖ Ib. p. 150. Prof. Silliman.

These localities in Barnegat and New-Lebanon are on the Barnegat limestone, which is, in some places, modified as a metamorphic rock.

The cause of the deposition of carbonate of lime to form stalactites, stalagmites, tufa, sinter, tufaceous marl, and incrustations, is, that the carbonic acid, which by its excess held the carbonate of lime in solution while in the earth, passes off when it flows from the surface, where the water can contain only an equal volume of the gas at the ordinary pressure of the atmosphere; or by partial evaporation of the water, a deposition follows equal to the quantity that the evaporated water held in solution. In most instances, both these causes are combined to produce the results. Rain water always contains some carbonic acid, and although its solvent power is small upon the limestones, it is nevertheless very perceptible in the course of ages upon the most dense and compact limestone rocks. Water that percolates into the earth acquires more carbonic acid, and its solvent power is still more distinct in limestone caves, most of which have been principally formed by the solvent power of carbonic acid in water.

Clay Balls, and Calcareous Concretions.

There is another class of calcareous concretions, commonly found in the tertiary and quaternary clay beds, but which are of alluvial formation. One division of them seems to be formed by segregation, like septaria and the various nodular masses imbedded in limestone, slate, and other rocks. They present a great variety of imitative forms; rarely spherical, except when grouped in botryoidal masses, as they sometimes occur in the clay and sandy clay beds around Newburgh bay; but generally flattened ovoidal, digitated, and more similar in form to the various shapes of cakes made for children, that we see in the baker's shops. They are formed between the layers of clay, at considerable depths from the *horizontal* surface; but I do not know of an instance in which they have been found at any considerable depth, in digging wells or making excavations, *at a distance from the edge of a clay bank.* They are commonly found where clay beds are crumbling or washing away, and they seem to form near the edges of the layers of the clay, where they are exposed to the weather. They are formed of the clay, but contain carbonate of lime sufficient to indurate them, and sometimes to slake when burned. At the brick-yards where these clay balls and concretions occur, they pick them out of the clay before grinding it; else the bricks will be of inferior quality, and burst to pieces when wet, in consequence of the slaking and expansion of the lime.

The other division is formed by organic causes. They are of almost all the shapes of a tubular, flattened ovoidal or annulated form, and almost universally have a hole through them; some not larger than a fine needle, others of the size of the finger or of the arm. They are formed in and between the layers of the clay, but never, it is believed, below the depth to which the roots of plants penetrate. They seem to be formed by the roots of plants absorbing the water, and perhaps the carbonic acid of the water in the earth, and rejecting the carbonate of lime that was held in solution by one or both. This, by its deposition, remains around the root or fibre, and indurates the clay. I have seen many examples in the Hudson valley

clay beds, where these clay balls were still penetrated by the living roots and fibres of trees and plants; others, where they were more or less decayed, but still showing the bark or the woody fibre, or both (generally the former); and others, where the cavity alone remained, without any appearance of organization in the cavity, except that in some instances the impression of the root remained where the clay was highly indurated. I have seen similar concretions, with holes through them, in the valley of the Connecticut about Middletown; and it is believed that they are common in clay beds, where the clay contains some carbonate of lime. The localities in the valley of the Hudson and its tributaries are so numerous, that it is unnecessary to specify more than a few, where they are most easily accessible for the greatest number of observers. The clay beds about Albany, wherever excavated, show them more or less abundantly, and of all the varieties mentioned.

The clay beds at and near Schoharie, Schoharie county, contain many of the common concretions. Between Lower Redhook and Rhinebeck landings, near the shore of the Hudson, I saw an oak tree that had been uprooted by the wind, with hundreds of these annular, tubular, and discoidal concretions dangling from its smaller roots and fibrous rootlets. They are not uncommon about Hudson, Poughkeepsie, Hyde-Park, Fishkill, and throughout the clay formation of the Hudson and its main tributaries, and Lake Champlain.

Various explanations and hypotheses have been offered to account for the origin of these concretions, which often assume the forms of art, or forms that might be supposed the result of organization; but after a careful examination of the facts in many places, I believe they may be referred to the causes before mentioned, viz. to *segregation*, or the attraction by which similar particles are brought together in masses, in any heterogeneous matter in which they may be diffused; to *excretion* from the roots of plants; or to the deposition of the calcareous matter held in solution by the water surrounding the rootlets, while the water is absorbed, and serves to nourish the plant.

2. Sulphates of Lime, Alumina, &c.

Sulphate of lime occurs in the First Geological District only as an alluvion, inconsiderable in quantity, and resulting from the decomposition of pyrites in contact with materials containing calcareous matter, or as a deposit from mineral springs.

In the Highlands, sulphate of lime is frequently seen incrusting hornblende and augitic rocks. One kind of hornblende rock is common, that is more or less distinguished by this mineral. It is formed by the decomposition of pyrites; and the acid combining with the lime and crystallizing, causes the rock to crumble. These masses, when imperfectly crumbled, generally have a yellowish and reddish brown colour, from the oxide and red sulphate of iron, while the interior of the mass is filled with thin plates and crystals of the sulphate of lime. It is very common about West-Point. Acicular sulphate of lime, very beautiful, was found incrusting augite rocks which overlaid white limestone, at an old mine hole on Anthony's Nose mountain, about three miles east of Fort Montgomery, near the top of the mountain. Magnetic pyrites occur both in the augite and limestone.

Acicular sulphate of lime was seen incrusting magnetic oxide of iron, at a mine where pyrites abound in that ore in the Phillips vein, eight and a half miles from Coldspring on the road to Putnam court-house in Putnam county. The specimens were very delicate and beautiful.

Near the junction of the water limestone with the underlying rocks, is a stratum abounding in pyrites. Sulphate of lime is formed in many places near this junction; and in one place, a trial of the pulverized rock was recommended as a substitute for gypsum,* as it is a limestone loaded with minute crystals of pyrites, which decompose and form a sulphate of lime. The material is stated to answer a good purpose, and to have produced an improvement in the luxuriance of vegetation (when scattered in stripes over the ground), that was visible at a great distance. This locality is at the High falls of the Rondout, in Ulster county. Numerous other localities were observed, where this pyritous stratum was near or interlaminated with limestone, or where sulphate of lime was forming; but so situated that it could not be used on account of the expense of transportation, or of its being too small in quantity.

Sulphate of lime is deposited from the water of some of the sulphur springs at Sharon, Schoharie county. Some of it is said to be anhydrous.

Sulphate of alumina, alum, and sulphate of alumina and iron, were seen effloresecing on rocks containing pyrites in many places. These salts generally accompany each other, and sulphate of iron is also found with them at most of the localities.†

In Dutchess county, two localities were pointed out to me by Prof. Merrick, where there is an efflorescence of alum and sulphate of alumina. It occurs as an efflorescence, and in tuberculated masses and stalactites. One is on the mountain about two and a half miles southwest of Ameniaville, in decomposing pyritous and dark colored mica slate, that was once supposed to contain coal; the other is about three miles south of the same village, in a similar rock. There is another locality in the township of Northeast. Prof. Merrick observed a locality of "alum slate," like that of Amenia, near the top of the hill east of Hurd's corners in Pawling.

In Putnam county, there is a locality of sulphate of alumina and iron, and of sulphate of iron, in Phillipstown, on Anthony's Nose mountain, about three miles from West-Point, at an old iron mine where the ore contains pyrites. The earth from this place was used many years since by some of the inhabitants, for dyeing. Another locality is near Luddington's corners, half a mile east, in Kent; another in the same township, four or five miles south, near Dean pond.

In Orange county, near Fort Montgomery, in several places these salts are found effloresecing on rocks containing pyrites.

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* Vide Assembly Document No. 50, Geological Report for 1840, p. 245.

† Alum has been described as effloresecing on the Catskill mountain (Cleaveland's Mineralogy, p. 228, and Webster's Catalogue, p. 12), as twelve miles west of Catskill; on the mountain four miles north of the Clove; and on the same mountain southwest of Cairo, in a stalactitical form. Also as existing in a spring on the north side of the mountain north of the Kaaterskill clove, one-quarter of a mile from Absalom Smith's (Robinson's Catalogue, p. 120; Silliman's Journal, Vol. 4, p. 249).

In Delaware county, alum and sulphate of iron effloresce at an old mine hole in Colchester, on Downe's brook, where copper has been supposed to exist; also at an old mine hole on Dry brook in Middletown, two miles from Arkville.

In Rensselaer county, about one and a half or two miles north of New-Lebanon springs in Stephentown, is a locality that has long been known. Sulphate of alumina and iron occur there, efflorescing upon the rock, which contains pyrites. Prof. Eaton has described the rock as *alum slate*.* Another locality is three miles north of Lebanon springs, eighty rods east of the road to Williams College, under a shelving ledge of argillite.†

In Hoosick township, near the Vermont line, a few miles east-northeast of Hoosick falls, is a similar locality, also in the metamorphic slates, and described by Prof. Eaton.‡ It is near the banks of the Wallomsack river, a tributary of the Hoosick, and within a mile of the Bennington battle ground. The locality is not of economical importance.

Alum has been found on the Helderberg;§ at several places in Saratoga county,‖ and at several on the banks of Fish creek in that county;¶ on the Shawangunk mountains, in slate rock,** and sometimes in the fissures of the grit rock of those mountains.††

Sulphate of alumina has been observed on the Helderberg mountain,‡‡ and in Saratoga county.§§

3. Nitrates of Lime and Potassa.

Nitrate of lime occurs in small quantity, it is said,‖‖ under the shelving limestone rocks on the left bank of the Rondout, a few rods below the High falls in Marbletown, Ulster county. It is known by its deflagrating on hot coals, like nitre. It also has been observed in small quantities in the old arches of Fort Putnam, near West-Point, in Orange county.¶¶ In both localities, carbonate of lime, sheltered from moisture except that of the air, is exposed to animal exhalations, which are the circumstances favorable to its formation. It is formed almost every where under such circumstances, and particularly under buildings. Advantage was taken of this fact in 1812 and '13, to make nitre for the manufacture of gunpowder, when our supply of this article from foreign countries was mostly cut off. Most of the shelving rocks that shelter an area which is kept dry, and especially those under which animals take shelter, and the caves where the earth is kept dry, or slightly moist, will afford one or both these salts. Large quantities of nitre have been made in such situations, in some parts of our country, and may be again, in case of a diminished supply from other sources.

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* Eaton's Geological Survey of Rensselaer County, p. 20.
† Silliman's Journal, Vol. 15, p. 244.
‡ Eaton's Geological Survey of Rensselaer County.
§ Silliman's Journal, Vol. 5. p. 269.
‖ Robinson's Catalogue of Minerals, p. 148.
¶ Ibid. p. 158.
** Pierce in Ibid. p. 150; Cleaveland's Mineralogy, p. 228.
†† Bradbury in Ibid. p. 150.
‡‡ Robinson's Catalogue of Minerals, p. 132; Survey of Albany County, by A. Eaton; Webster's Catalogue of Minerals, p. 6.
§§ Steel, Survey of Saratoga county.
‖‖ Geological Report, Assembly Document, N. Y., No. 50, 1840, p. 245.
¶¶ Prof. J. B. Nott, in Webster's Catalogue of New-York Minerals, 1824, p. 21.

4. Sulphate of Magnesia, Muriate of Soda, and Muriate of Lime.

Sulphate of magnesia is frequently found efflorescing in acicular crystals, or as a pulverulent powder with the sulphate of lime, at and near the pyritous stratum at the base of the water-limestones around the Helderberg mountain, in Albany county; also at the locality of sulphate and nitrate of lime, a few rods below the High falls of the Rondout in Marbletown, Ulster county.* It may probably be found in many localities along the base of the water limestone series, from Sharon springs, by Schoharie, Bethlehem, Kingston, and thence through the Mamakating valley to Carpenter's point on the Delaware, and wherever iron pyrites are associated with the magnesian limestone. It also occurs in some of the mineral springs. A strong spring of epsom salts occurs at Coeymans in Albany county, and the same salt effloresces on the clay at the same place;† and on another clay bank at Lansingburgh, six miles north of Troy,‡ on land of Judge Hickock. Sulphate of magnesia has been found on a calcareous sandstone overlying limestone, ten miles northwest of Coeymans, on the Helderberg mountain in Albany county;§ and at another locality on the Helderberg, crystallized, but the locality not specified.‖ Another locality has been observed at Hudson.¶

Muriate of soda has been found in the interior of the First Geological District only at licks, where animals have been in the habit of resorting to lick the clay and soil, where saline matters effloresce or ooze from the earth. Deer-licks are common in Delaware county, and they probably were in many of the other counties, while they were inhabited by the wild animals; but a knowledge of them is lost, or confined to the old inhabitants, and will soon be entirely obliterated, unless the localities be published by those interested in preserving such knowledge. The *licks*, as they are called, do not always indicate muriate of soda, though the principal ones contain that salt.

Salt is said to have been formerly made by the hunters, three and a half miles from Colchester, Delaware county,** on the land of George Doane, on the east fork of the west branch of Downe's brook, one fourth of a mile north of the road from Walton to Colchester. The water was not perceptibly saline to the taste at the time of my visit in September, 1840; but there was distinct evidence that it was a place of resort for cattle, although there was an abundance of good water near the same place.

At a salt lick three and a half miles from Delhi, Delaware county, in the valley of Elk creek, a salt well was bored three hundred and ninety-four feet a few years ago, and the brine became stronger as far as they bored. The strength was not ascertained, but it

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* Assembly Document No. 50, 1840: Geological Report, p. 245.
† Eaton. Silliman's Journal, Vol. 15, p. 241 and 242.
‡ Id. Ibid. Vol. 15, p. 242; and Agricultural Survey of Rensselaer county, p. 28.
§ Cleaveland's Mineralogy; Webster's Catalogue, p. 6; Geological Survey of Albany County.
‖ Robinson's Catalogue of Minerals, p. 132; Webster's Catalogue, p. 6; Geological Survey of Albany County.
¶ Ibid.
** Assembly Document No. 50, 1840: Geological Report, page 233.

exceeded that of the water of the ocean.* These licks and the salt well are in the rocks of the Catskill division, but the well probably penetrated into the rocks of the Erie division. Several hundred barrels of salt were made, and it was very white, and a superior article for table use. The water still flows from the well, but the quantity could not easily be ascertained.

The basin or trough-form† in which the strata are deposited,‡ renders it not improbable that brine might be obtained by deep boring in the valley of the Delaware, between Deposit and Narrowsburgh, in the valleys of both branches of the Delaware, and the lower parts of their main tributaries; and possibly in the valley of the Susquehannah about Sidney, in that of the Mongaup, and of the Neversink above Cuddebackville.

The water of the ocean has been but little used on the coast of New-York for the manufacture of salt, although extensively employed for that purpose on other parts of the coast of the United States, and in various parts of the world. The concentration is most generally effected by solar evaporation. The salt marshes of the coast of New-York, which are extensive, are well adapted to this branch of manufacture, either by solar evaporation in large shallow reservoirs like those of some foreign countries, or in vats like those of most of the coast salt-works of the United States; or else by freezing the water in shallow reservoirs to concentrate the brine and bring it to the point of crystallization, as is done at some of the Russian salt-works.

Another method of evaporating very weak brine is pursued at Moutiers in the Alps, which, in my opinion, may be introduced with advantage on our coasts. This method consists in exposing a great surface continually to the action of the winds, either by permitting the brine to trickle down cords attached to troughs twenty or thirty feet above the ground, leading to other troughs below; or by permitting it to trickle through loose brush, thrown into open frames of slight timber-work, between the upper and lower series of troughs. The lower series of troughs conducts the concentrated brine to reservoirs. The location usually selected is on a hill side, where the brine, coming from one set of frames, flows directly into the upper conductor of another set at a lower level, the top of which is on a level with the bottom of the

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* Ten bushels of salt were made per day in eight kettles, with a consumption of two cords of wood. This will enable the manufacturer to form an approximative estimate of the strength of the brine.

† This is in a *bay*, if we may so term it, a trough-shaped depression, connected with the great basin containing the salt water that fills the pores and fissures of the rocks in and below the Coal formation of Pennsylvania, Maryland, Virginia, Tennessee, Alabama, Kentucky and Ohio. An anticlinal axis, with a very gentle swell, separates this basin from that of the Green River and Wabash basin, which includes Western Kentucky, Indiana, Michigan, Illinois, part of Missouri, &c.

‡ The rocks between the Susquehannah and the Catskill mountains dip slightly towards the valley of the Delaware; and in Schoharie county, they dip southward, giving a basin-shaped form to the stratification. It is a fact that has been forced upon my attention by extended observation, that many of our salt-well districts in the United States are in depressions of the strata; in other words, they are within the undulations, as troughs or basins in the strata.

Whatever be the origin of the salt water of our salt wells and licks, whether from salt in mass, or disseminated in the superincumbent rocks, as some of my colleagues and others believe, or from the water of the ocean, (for there is indubitable evidence that it formerly covered all these rocks,) the *fact* that *salt water* is *generally* found in such depressions of the strata, is believed capable of demonstration.

preceding, and from the second set of frames passes to a third in the same manner, until it is concentrated nearly to the point of crystallization. It is then boiled down, and crystallized in the usual way. These combinations of frames are several hundred yards in length, with a breadth of a few feet. Their length is placed in a direction perpendicular to that of the prevailing dry winds, in order that the greatest effect may be produced. The sulphate of lime, and other salts of moderate solubility, are deposited on the cords or brush, which, after a time, become coated with a solid stony crust of considerable thickness. This method is employed at the place mentioned, in evaporating water containing only one and six-tenths per cent. of salt, with considerable profit. The water is evaporated by this method to one-sixteenth of its original volume, and then brought to the point of crystallization by boiling.*

All these methods are capable of useful, and, it is believed, of profitable application on the southern coast of New-York.

Muriate of lime occurs in almost all the spring waters of the Hudson valley, and particularly in those that issue from the clay beds of the tertiary of that valley, and is the principal cause of the "*hardness* of the water," or its quality of decomposing soap. In 1819, Prof. Eaton examined most of the waters from Albany to Blenheim in Schoharie county, and along the banks of the Hudson for more than one hundred miles, and also along the Boston road to Connecticut river; and in 1820 and 1821, Profs. Eaton, T. R. Beck and L. C. Beck, tested the hard waters of Albany and Rensselaer counties. In all these cases, the wells were in the marly clay, and contained muriate of lime.† The nitrogen springs contain muriate of lime.‡

5. Springs.

Springs are caused by the water percolating downwards from the surface of the earth, until it meets some stratum that is not sufficiently pervious to permit it to pass through. The water accumulates on this, until it rises to such a level as to find an outlet.

Springs are the causes of many geological phenomena, with which it is important to become acquainted. The effects of springs in producing land-slides, and in depositing masses of calcareous matter, have already been considered. Their effects in forming valleys, and in the transfer of various subterranean mineral substances to the surface, are yet to be discussed.

Springs of water of ordinary purity, unless they be very large, produce but little effect on the surface along which they flow, except in a few instances, where, from local causes, or the exposure of particular strata, the excavating action is sufficiently obvious to be taken into account. When spring waters hold much mineral matter in solution, their effects are more marked, and have long attracted attention.

The substances found in spring waters are numerous. The most common are lime, iron, magnesia, silex, alumina, soda; carbonic, sulphuric, hydrochloric and hydrosulphuric acids;

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* Silliman's Journal, Vol. 20, p. 219; Mather's Geological Report of New-York, 1837, p. 87; Vanuxem's Geol. Report, N. Y. 1841.

† Eaton. Silliman's Journal, Vol. 15, pp. 242, 243.

‡ Eaton. Geol. Survey of Rensselaer county, p. 30.

carburetted hydrogen, nitrogen, sulphur, naphtha and petroleum. Some of these, and others not mentioned, that are of little geological importance, are valuable in a medicinal point of view, and for yielding substances of value in the arts.

Carbonic acid is one of the most common substances in mineral waters. It is a well established chemical fact, that carbonates are soluble in an excess of carbonic acid. As spring waters containing carbonic acid flow along the fissures of limestone, the carbonic acid is continually exerting its solvent action upon the rock, and transporting the dissolved carbonate of lime to distant parts. This offers a ready and satisfactory explanation of the numerous extensive caverns in limestone districts, to which they are almost exclusively confined.

Water will retain only its volume of carbonic acid at the common atmospheric pressure; but by increasing the pressure, more will be absorbed in proportion to the force employed. The effect of this is seen in many mineral springs, where the water sparkles by the extrication of bubbles of the gas, as the pressure is relieved by the water issuing from the spring. If such waters contain a carbonate of slight solubility, it is deposited in proportion as the carbonic acid gas escapes. Such has been the effect at the High-rock spring at Saratoga, the Sharon springs, Lebanon springs, and many others that might be mentioned.

Chalybeate Springs.

Chalybeate waters contain carbonate of iron, held in solution by carbonic acid; and the adjoining valleys and marshes into which such springs flow, always contain bog iron ore, or soil stained by limonite, unless they flow into a stream so as to prevent a deposition of the ferruginous matter.

The following localities have been examined during the progress of the Geological Survey, where chalybeate water flows from the earth.

Near Upton's pond in Stanford, Dutchess county, Prof. Merrick examined a small chalybeate spring, from which an unusual quantity of iron ore was deposited.

Near the village of the Brick-yard Shakers in New-Lebanon, Columbia county, Prof. Briggs examined the water of a spring highly charged with iron, and iron ore was deposited in small quantities.

Two miles south of the above village, the same observer saw a similar spring near the road; and in several places near the road, south of Mr. Bailey's in New-Lebanon, a reddish deposit was made by the spring waters. He also observed ferruginous matter deposited from water near Mr. Grant's in New-Lebanon, on the east side of the valley, and three quarters of a mile from the turnpike road.

A small chalybeate spring was seen on the east side of the road, half a mile south of Canaan centre, Columbia county; another two miles northeast of the Lutheran church in Milan, Columbia county, on the land of John I. Link.

A chalybeate spring was seen on the west side of the road that leads up the left bank of the Susquehannah, between Sidney plains and Unadilla, and another between Unadilla and Franklin, both in Delaware county.

A copious chalybeate spring was observed in the meadow near the brook about two miles from Bloomville, on the road to Kortright centre, on land of Nehemiah Every, Delaware county. This flows from alluvion overlying the rocks of the Catskill division.

Chalybeate water flows from the marsh on the Beaver-dam flats, a quarter of a mile above the mouth of the Stratton-falls brook. Most of the springs are now covered over, in consequence of a bed of gravel and stones having been swept into and across the Delaware during the heavy freshet of the winter of 1838–9, by the Stratton-falls brook, so as to dam the Delaware up about two feet above its former level. The current of the river is not sufficiently rapid to sweep away the obstruction, and regain its former level; and above, the water stands in a pool, dammed up so as partially to flood the flats in times of high water.* These springs flow from the alluvion overlying the rocks of the Catskill division.

Ferruginous deposits, indicating chalybeate springs, were observed in many places along the route of the Erie railroad between Chehocton and Deposite in Delaware county. These waters flow from the Catskill division of rocks.

A chalybeate spring was seen on the farm of James Weed, in the valley of the west branch of the Delaware in Walton, three miles above the village, in Delaware county. Bog ore is deposited from the water. This is from the Catskill division of rocks.

In Greene county, three miles from Oak hill, on the road to Freehold, north of the turnpike, on the farm of Walter Barlow, a chalybeate spring was examined. This issues from the drift overlying the lower part of the Catskill division of rocks, or the Chemung group.

In Orange county, a mile and a quarter south of West-Point, on Mrs. Kinsley's farm, is a mineral spring containing carbonate of iron in solution. It is said to be a strong chalybeate spring at some seasons of the year, but it was only slightly chalybeate at the time of my visit, which was after heavy rains. This issues from gneiss rocks.

In Rensselaer county, in Sandlake township, a chalybeate spring was observed by the road-side on the land of Mr. Ricord. It issues from a gravel bank by the road-side, and is sufficiently copious to be useful. It is about a mile, perhaps less, eastward from the village in the west part of Sandlake township, on the road to Albany from the village of Sandlake. It is from the Hudson slate group of rocks.

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* Several similar examples to this were observed on the St. Peter's river, in the autumn of 1835, when making a geological exploration of that part of the United States, in company with Mr. G. W. Featherstonhaugh, under the authority of the United States. The torrents from the hills had swept in such quantities of gravel, pebbles and boulders, from the drift formation (which is so extensive, thick and well characterized in that region), as to dam up the river, or confine it to a narrow channel, and sometimes cause a "*rapid*," with a fall of two or three feet in a hundred yards. This fact seemed to explain the numerous lacustrine deposits along that river through which the stream had cut its channel, leaving banks of alluvion, containing sometimes peat and lake marl, but more frequently an argillaceous alluvion as fine as clay, but more calcareous and light, containing the Cyclas, Planorbis, Physa, Lymnea, and other small fresh-water lacustrine shells, and probably abounding in the coverings of infusoria. These deposits are in some places several miles long and broad. They seemed to have been forming during a long time; and the obstruction that had caused the lake and marsh had been swept away by the greater velocity of the current during some great freshet, and then the river had cut its channel through the alluvion it had formed. This process seems to be in operation in the Delaware. The *beavers*, formerly very abundant in the valley of this stream, have dammed it up in many places, and made pools of still water. The results from both causes are similar.

At Ballston-Spa is a chalybeate spring, which is much used. It is supposed to issue from near the junction of the drift with the graptolitic slate of the Hudson river slate group.

Prof. Briggs observed chalybeate springs issuing from the gravel banks near the shore between West neck and Lloyd's neck, in Suffolk county, Long island.

The following springs were described to me, but not examined, and from the description, were judged to be chalybeate :

One near the road from Troy to Schenectady, four or five miles from Troy, Albany county.

Another between East kill and Cairo on the Catskill mountain, on land of Judge Austin, Greene county. The water is stated to act as an emetic a few minutes after it is swallowed, but to possess little taste. It flows from the rocks of the Catskill division.

Another is said to occur near North-Blenheim post office, in Schoharie county. It probably issues from the rocks of the Portage or Chemung group, or possibly from the Hamilton group.

Mineral springs are said to occur on the farms of Peter Hoosis and Mr. Waterburgh in Stuyvesant, and another near New-Concord, on the left of the road from Kinderhook to that place. These are in Columbia county.

A chalybeate spring is said to flow from the base of Barker's mountain, half a mile northwest of Kline corners in Amenia, Dutchess county.

A mineral spring flows from the base of the high hill called the Roman Nose, in the valley of the Schoharie kill, near the road from Middleburgh to Byrnville.

Hepatic or Sulphur Springs.

The waters of these springs have an unpleasant odor like sulphuretted hydrogen, the washings of a gunbarrel when foul, or addled eggs. Silver dipped in the water becomes tarnished, and often black; and this effect is produced even when silver is exposed over or near the water, if the odor be strong. The presence of these springs is frequently known even when at some distance from them, if the water be copious, or strongly impregnated, in consequence of the peculiar odor which is diffused in the air around them. They are almost uniformly associated with metallic sulphurets, and generally with iron pyrites (sulphuret or bisulphuret of iron). It is generally supposed that the sulphuretted waters are formed by the decomposition of water furnishing oxygen, both to the sulphur and the metal, while the hydrogen combines with another part of the sulphur, as hydrosulphuric acid, and is retained dissolved in the water, under the pressure where it is formed. By its solvent power, it holds various other mineral substances in solution, which are entirely or mostly deposited after they flow from the earth, unless easily soluble in water alone.

The sulphur spring in the south part of Greenbush, Rensselaer county, on the farm of Mrs. Genet, has been known for many years, and has been described by Prof. Amos Eaton, in his Report on the Agricultural and Geological Survey of that county, p. 29. It emerges from the clay beds of the Hudson valley tertiary, overlying the black slate of the Hudson-

river group, which, in that vicinity, is loaded with pyrites. This may be seen at the head of a deep rocky ravine near the spring. Limestone is also associated with the slate, and the rocks are very much deranged in position, and contorted. The water of this spring is strongly hepatic, and sufficiently abundant to make it useful to a great number of such persons as require this kind of mineral water. It is also favorably located near the Hudson, within a few minutes ride from Albany on the railroad, with a pleasant healthful country and fine views around.

There is also another sulphur spring in Greenbush, opposite the city of Albany, which has also been described by Prof. Eaton in the work referred to above, p. 29. Another similar spring emerges from the black glazed argillite near the Old Bank place, at the north end of the city of Troy (Idem, p. 29).

A sulphur spring flows from the base of the tertiary terrace on the edge of the alluvial flats of Kinderhook creek, on the Best farm, one and a half miles north from Kinderhook, Columbia county. Other springs of similar character are said to rise in the adjacent marsh, and also in a marsh south of Kinderhook. Another occurs near the township line between Claverack and Ghent, one mile east of Miller's tavern, Columbia county.

A sulphur spring is said to occur on the farm of Mr. Livingston of Oak-hill, opposite Catskill, and about one-fourth of a mile east of his house. This also is in Columbia county.

In Washington county, in Argyle, three or four miles from Sandy-hill, is a sulphur spring. I was informed of this by a gentleman of Sandy-hill, who has examined it.

A small sulphur spring flows from the base of the mountain, a mile and a quarter north-northwest of Ameniaville, on the land of Mr. Thomas Ingraham. At the time of my visit, its odor was so slight as to require to be taken into the mouth to perceive that it was a sulphuretted water.

The Columbia spring near Hudson, the spring at Amenia, and that of Kinderhook, have some reputation for the cures effected by them.

A sulphur spring was observed on Mr. McNaughton's farm, between Lebanon springs and the Shaker village, in Columbia county. A sulphur spring was examined near the north line of Claverack by Prof. Merrick, and there were several more in the vicinity, some strongly impregnated. Sulphur springs are common throughout the range of the black slate of the Hudson-river group.

A sulphur spring rises from the alluvial gravel overlying the slates of the Hamilton or Portage group of rocks, on the bank of a creek about three-fourths of a mile west of Greenville village, Greene county. It is on land of Mr. Francis Hickok. It is well located for use, within a few miles of the Hudson river, in a well cultivated country, and in the bracing air of the Catskill mountains.

In Albany county, there is a sulphur spring of moderate strength on the farm of Mr. Weeden. It is in the valley of Fox creek, three miles from Preston hollow, and four miles from Rensselaerville. The water is much used by the people in the vicinity. It is said to be diuretic in its effects.

A sulphur spring issues from the clay beds about four miles west of Athens in Greene county, in a valley at the base of the water-lime series. These limestone rocks dip to the west, and present a mural front to the east.

A sulphur spring was examined about a mile west of Springtown in New-Paltz, Ulster county. It rises from the alluvial gravel overlying the rock of the Hudson slate group, in the bed of a small brook; and if the waters of the stream were excluded, the water would be strongly hepatic. Gas rises in bubbles at intervals of a few seconds. The spring is near the base of the Shawangunk mountain, and opposite Buntico point, a high precipice, where it is believed two great fractures of the strata intersect each other. It is not improbable that this spring may have some connection with the northwest and southeast fracture.* There is a sulphur spring, it is said, in Esopus, near the village; and another on Mr. Snyder's land, at Rosendale, Ulster county.†

A sulphur spring is said to occur near the Katerskill, two miles west of Catskill village, Greene county, on Henry Palmer's farm, with gas bubbling up through the fountain; and another a mile from the one just mentioned, on the other side of the creek, on Peter Ackler's farm. These two springs can not be far from the junction of the Water-lime group with the Hudson slate group. I did not visit them.

There is a mineral spring, reported to be a sulphur water, but perhaps chalybeate, on Mr. Thomas' farm, on the east branch of the Delaware, three miles above Chehocton in Hancock, Delaware county.

A small sulphur spring, and of little strength, occurs on the land of Mr. John Edwards, two and a half miles southwest of Sag-Harbor, Suffolk county, Long island. It issues from that division of the tertiary of Long island, that forms the hill range through most of the island.

Sulphur waters have been described by Dr. Steel, in the vicinity of Saratoga and Ballston.‡

The most copious, and probably the most important sulphur springs of the First Geological District that are known, are the Sharon springs, in Schoharie county. These springs are numerous, and their united waters form a mill stream in the distance of a few hundred yards. Some of the springs at this place are common limestone water, but most of them have a strong hepatic odor; and frequently, before rain, the odor can be perceived to some distance in the valley.§ Gas rises from some of the fountains. The principal deposits from these

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* Buntico point, Sam's point, Great Mogunk, High point, etc. are high cliffs on the Shawangunk mountain, between Shawangunk and Rosendale, caused, it is believed, by upheaves at the intersections of great fractures of the strata. They are prominent landmarks; and to them, as conspicuous objects, the lines of the old patents of the country were directed.

† There is a small and weak sulphur spring in Hurley, Ulster county, near the road from Kingston to High falls, at the junction of the hydraulic limestone rocks with the dark overlying calciferous slate. (Vide plate 8, fig. 9.)

‡ American Journal of Science, XXI. p. 184; and "Analysis of the Mineral Water of Saratoga and Ballston, &c." By JOHN STEEL, M. D.

§ This fact was mentioned to me while examining the springs, as almost a sure sign of rain, and it was inexplicable to me at that time; but since, other facts have come under my observation, that offer an apparent explanation.

1. It is well known that the fall of mercury in the barometer, or a diminution in the pressure of the atmosphere, precedes a storm.
2. I have observed here, at my residence and in the vicinity, during a low state of the barometer, where small streams have

waters are carbonate and sulphate of lime, and sulphur. The springs rise from the junction of the Water-lime and Onondaga-salt groups.

With the exception of the Sharon springs, almost all the sulphur springs mentioned are situated on or near lines of fracture, or of great disturbance of the strata by some subterranean force. These lines of disturbance will be mentioned in another place.

In addition to the above localities, Prof. L. C. Beck has mentioned the Chappequa spring, three miles and a half east of Sing-Sing, Westchester county; one near Newburgh; one at Coeymans landing; one in Guilderland; one in Wendell's hollow in Albany, and one in Watervliet.*

Acidulous Mineral Waters.

The most important are those containing carbonic acid, and which are more or less sparkling from the continual ascent of small bubbles of the gas to the surface, and throwing up minute globules of water. This extrication of gas is caused by the pressure under which it had absorbed the gas being relieved, on flowing from the surface of the earth. This extrication of gas, rapid at first in proportion to the quantity contained, continually diminishes; until, after standing in a vessel a few hours, it contains but little, and has lost its acidulous taste. The carbonic acid, by its solvent power, holds various mineral substances in solution, but those most abundant are usually carbonates of lime and of iron.

The acidulous waters of Saratoga and of Ballston in Saratoga county, are the best of the kind in the United States, and probably equal if not superior to any in Europe, or in other parts of the world. The waters are a pleasant and refreshing beverage to persons in health, and are of great service in some diseases.

The Saratoga springs are supposed to derive their mineral qualities from the limestone and slate beds that underlie the town, or they may be more deeply seated; but the water is usually obtained from beneath the clay and "hardpan" beds that overlie the rock. Limestone rock that belongs to the calciferous group, crops out in the village, and in many places in the vicinity, and the primary rocks are not far distant on the north and west.

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been dry during a drought, that the springs and little streams begin to flow, and I think, from the limited observations made, more abundantly in proportion to the diminished length of the mercurial column, and that they cease to flow as the mercury rises.

If similar facts have been observed in other places, they have not come to my knowledge. Springs that contain gaseous matter, or that are connected with subterranean chambers filled with air or other gases, might be expected to be influenced by changes of barometric pressure, and even cease to flow when the barometer ranged high. The barometer has its regular *daily variations*, independent of its ordinary variations, and perhaps this may aid in the explanation of the ebbing and flowing springs, and some other phenomena connected with springs that have not been explained. It may be proper to state, that in the region where I reside, (viz. in the coal region of the Ohio,) the springs may be considered as influenced by gaseous matter, all deep borings suffering gaseous matter to escape. The deeper borings, as the salt wells, and the salt licks, evolve carburetted hydrogen; and those more shallow, carbonic acid. Carbonic acid is continually bubbling through the water of my well at sixty-two feet in sandstone rock.

I trust scientific men may examine this subject, where they may be favorably situated for observation; but it is presumed that the effects will be *most marked* where the waters contain gaseous matter in abundance, or where they may be connected with caverns that would receive the influence of atmospheric pressure, *only* through the aperture where the water emerges.

* Prof. Lewis C. Beck. N. Y. Geol. Report for 1838, p. 55.

Saratoga Springs.

Dr. JOHN STEEL, long a resident physician at Saratoga, has given an accurate account of these springs.* Professors Eaton and Lewis C. Beck, Dr. Meade and others, have repeatedly examined them; and as Prof. BECK, the Mineralogist of the Geological Survey, has reëxamined them, his report will contain many details that will be unnecessary and out of place in this, which is devoted to those facts immediately connected with geology.

The mineral waters of Saratoga have become celebrated for their medicinal qualities, and for their agreeable acidulous taste, and are now resorted to annually by thousands. The springs are mostly situated in a low marshy valley near a ridge of limestone, and rise from a bed of blue marly clay that underlies the valley and the sandplains of the vicinity. The water sometimes rises from the clay, sometimes from a fissure or seam in the underlying limestone, and sometimes from a layer of quicksand. At the depth of thirty or forty feet, the clay is underlaid by a stratum of boulders.

All the mineral fountains at the village, more than twenty in number, possess the *same general qualities;* varying in strength, or relative proportions of the mineral constituents, and the presence or absence of some particular substances. The High-rock spring is justly considered as one of the natural curiosities of our country. It has been long known, and was highly valued by the aborigines of the country, but has never been described except perhaps in the newspapers, until described by Dr. John Steel in the American Journal of Science,† where a drawing is given to illustrate its appearance. (Vide Plate 35.) Dr. Valentine Seaman, in 1809, published an imperfect drawing of it, which is believed to be the only other one that had been published; and in his description of this spring, he says, "The more we reflect upon it, the more we must be convinced of the important place this rock ought to hold among the wonderful works of nature. Had it stood on the borders of the *Lago d'Agnano,* the noted *Grotto del Cani,* which burdens almost every book which treats upon the carbonic acid gas since the peculiar properties of that air have been known, would never have been heard of beyond the environs of Naples; while this fountain, in its place, would have been *deservedly* celebrated in story and spread upon canvass, to the admiration of the world, as one of its greatest curiosities."‡

The marshy valley in which the mineral springs are situated, is bounded on both sides by steep banks, twenty to forty or more feet high; that on the east being composed of sand and gravel beds, overlying the clay, and that on the west, of loam, sand and gravel, reposing on limestone (the Calciferous group), which is exposed in some parts of the village. The banks have been cut down and the marsh filled in, in some places, so as to modify the original form and appearance of the ground. From the base of both banks, opposite the southern end of

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* STEEL. Silliman's Journal, Vol. 16, pp. 242, 246. † Ibid. pp. 341, 345.

‡ Dissertation on the Mineral Waters of Saratoga, 1809; and Silliman's Journal, Vol. 16, pp. 341, 342.

the village, fresh-water springs break out; the water is collected in a reservoir, and, by means of a forcing pump, distributed through the village.

The *Rock spring* is near the limestone rock on the west side of the marsh; and the tufa, in which it is encased, rests on the clay, it is supposed, or is but slightly cemented to it. The case in which this spring is contained, and which is represented on Plate 35, is of a conical form, hollow, with an opening in the top ten inches in diameter. The cone is of nearly uniform thickness; a mere shell a few inches thick, formed of tufa deposited from its own waters as it overflowed from the top, gradually narrowing as it became more elevated, until the pressure of the column of water within caused it to find a partial outlet at some other point. The water, since it has been known by the white people of our country, has never reached the top of the cone, but remains at about the same level, two feet below the top of the cone, and also about two feet above the level of the ground around. The water within is in a state of constant ebullition, by the escape of carbonic acid rising in bubbles; and this gas, in consequence of its specific gravity, fills the capacious cavity from the water to the opening above, out of which it flows down the sides of the cone. Experiments may here be performed to show the effects of this gas on animal life, and in extinguishing burning combustibles. The tufa of which the cone is composed shows it to have been formed in the way mentioned, as it is composed of parallel layers more or less waved and undulated, containing the impressions of leaves, small sticks and twigs.

The following are the dimensions, as given by Dr. Steel:

	FEET.	INCHES.
Perpendicular height,	4	00
Circumference of the base,	26	8
Length over the rock from north to south,	11	7
Length over the rock from east to west,	10	9
Top of the rock to the surface of the water,	2	4
Depth of water in the cavity of the rock,	7	8
Diameter of the hole in the top of the rock,	0	10

An opinion formerly prevailed, that the rock had been fractured by the fall of a tree, as the cause of the depression of the water below the top, but without any apparent foundation. In 1767, the spring was visited by Sir William Johnson, then Indian Agent, residing at Johnstown. The water was then several inches below the top of the rock. *Loran Tarbel*, an aged chief of the St. Regis tribe of Indians, told Chancellor Walworth, that he visited the spring when a boy, and was told by the indians that it once overflowed; but that owing to some of their women bathing in it (ἐν ἀκαθαρσία ὄντες), the water sunk into the rock, and never after showed itself above it.

The wonderful stories related by the early settlers and hunters, of the effects of the waters of this spring in the cure of diseases, are still remembered and related by their descendants; and these, with the singular form and nature of the rock, continue to give them a higher degree of importance, perhaps, than the facts will warrant.

It is well known that there are a number of springs at Saratoga, the waters of which bear a general resemblance to each other. But owing either to some difference in the chemical composition, or to the influence of fashion, some particular spring has always been more celebrated than all the rest. Such is at present the case with the Congress spring, and the chemical composition of its waters will unfold to us that of several others found in its immediate vicinity.

Composition of a pint of the water from the Congress Spring.

According to Prof. J. F. DANA.

	GRAINS.
Chloride of sodium,	54.3
Carbonate of lime,	18.0
Carbonate of magnesia,	4.0
Carbonate of soda,	2.0
Silica, with a trace of iron,	
Total,	78.3

	CUBIC INCHES.
Carbonic acid gas,	39.1
Azote,	0.9
Gaseous contents,	40.0

According to Dr. STEEL.

	GRAINS.
Chloride of sodium,	48.13
Hydriodate of soda,	0.44
Bicarbonate of soda,	1.12
Bicarbonate of magnesia,	11.97
Carbonate of lime,	12.26
Carbonate of iron,	0.63
Silica,	0.19
Hydrobromate of potassa,	trace
Total,	74.73

	CUBIC INCHES.
Carbonic acid gas,	39.00
Atmospheric air,	0.87
Gaseous contents,	39.87*

* Prof. L. C. BECK. Report on the Geol. Survey of N. Y. 1838, pp. 49, 50.

Ballston Springs.

The water of the Ballston springs rises from a bed of quicksand, beneath the bed of clay filled with pebbles, boulders and gravel, and which is commonly called "hardpan." This sand bed is supposed to rest on the fucoidal or graptolitic slate, (and this slate is seen in place at a very short distance.) The water is acidulous, and more or less sparkling. The proprietors of these springs have difficulties that have thus far proved insurmountable. The mineral water rising through a bed of quicksand, carries much of this sand along with it, and this packs so tight in the tubes as to obstruct the free flow, and frequently causes it to break out elsewhere. The springs are thus lost. Springs of fresh water also frequently break into the wells, and dilute the mineral qualities of the water. This last may be obviated by tubing down the springs to some little depth below the issue of the fresh water, as they do in salt wells; but the tube would probably become so tightly packed with sand as to obstruct the flow. It is probable that the mineral qualities of the water originate at the contact of the fucoidal slate with the underlying trenton limestone, which is probably not more than fifty feet below the level of the valley at the springs. If this be true, (and it is thought highly probable,) mineral water may probably be obtained in a permanent fountain, and free from the difficulties the proprietors now labor under, *by boring into the slate rock* (at some suitable point, at as low a level as practicable,) *until they strike the limestone below.* Water impregnated with carbonic acid would *probably* rise from this junction, and perhaps before, if the drill should strike a seam or joint of the slate. It is necessary to select a point where the slate rock can be uncovered at as *low* a level as practicable, else the water might not rise high enough to overflow at the surface, which is always desirable.

A well was dug at Ballston-Spa, near the creek, during the spring or winter of 1840; and after digging some thirty or forty feet through the hard aggregate of clay, gravel, pebbles and boulders, the man in the well struck his crowbar down while digging, and it nearly slipped from his hand, striking through into a softer material. The bottom of the well is described as then swelling up and bursting, with a torrent of water following, so that it was with difficulty the man escaped from the pit. A stream sufficient to drive a mill continued to flow from the well from that time until the period of my visit in June. The water was slightly acidulous, and seemed to be a mixture of the mineral water of this vicinity with fresh unimpregnated water.

Should it be deemed advisable to bore for water at Ballston-Spa, I would advise the boring to be carried even into the calciferous sandstone, if water should not be obtained before; for the source of the mineral qualities may lie deeper than the junction of the trenton limestone with the slate. At Saratoga, the source of the water is supposed to be in the limestone; and this limestone, which is the lower portion of the Mohawk, or upper part of the calciferous sandstone, must lie at a depth of one hundred to one hundred and fifty feet at Ballston. I would not strongly recommend such a boring, as it might very possibly penetrate even below the level of the source of the mineral qualities, without striking any seam or fissure through

which the water would rise; but the possibility of obtaining a permanent spring in that place, is worth risking something.

Dr. Steel has described these springs, as well as those of Saratoga.* In regard to the Saratoga and Ballston waters, Prof. Silliman has justly remarked, that "the mineral impregnation of the waters, in the two places, is substantially the same, differing only in proportions. If the saline ingredients are in less quantity at Ballston than at Saratoga, there is a greater predominance of iron; and the carbonic acid gas being abundant, very delightful acidulous chalybeate waters are thus afforded. Saratoga and Ballston must be regarded as one grand system of springs, depending upon the same general causes; and the variety that exists between the different springs is altogether desirable, and adds much to their utility. The repeated eruption of new springs, especially at Ballston, (either by accident, or in consequence of boring,) is an interesting geological circumstance; and the expulsion of the water in copious jets above the surface of the ground and boiling with carbonic acid gas, evinces that there is much power condensed below, and renders it not improbable that the elevating agent is carbonic acid gas itself."†

Prof. Beck has examined these springs, and of them he remarks, "The springs at Ballston are mostly situated in the valley of the stream which passes through the village. The bed of this stream is slate, and it is probably in this formation that the carbonated waters have their origin. An interesting group of springs occur in this village, near the present bathing house. Here we have the United States spring, which is acidulous; at the distance of nineteen feet is the Fulton chalybeate spring; while in an opposite direction, and within twelve feet of the former, is the Franklin sulphur spring. Thus there are three springs, differing considerably in their chemical composition, rising within a few feet of each other. The United States spring is highly charged with carbonic acid gas, while the others contain only a small portion of it.

"From several of the springs at Ballston, there is a discharge of gas in smaller or larger bubbles, which does not unite with the water. At the Park spring in rear of the Village Hotel, minute portions of gas are continually rising through the water; but at an interval of a minute, the whole well is agitated by the evolution of a comparatively large bulk of the gas. This gas, which in all cases is the carbonic acid, also rises in great abundance through the water of a well near Low's spring, and in various places in the valley of the stream. A few years since, there was a very remarkable and indeed almost volcanic discharge of it near the old factory, which threw up the water of the creek several feet into the air; but the gas soon diminished greatly in quantity, and can now be observed rising only in small bubbles through the bed of the stream.

"From these facts it is evident that here, as at Saratoga, there are certain agencies in operation, which cause an abundant evolution of carbonic acid. That this gas originates at great

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* Analysis of the Mineral Waters of Saratoga and Ballston, with an account of their medicinal properties, etc. by JOHN STEEL, M. D.; and American Journal of Science, Vol. 21, p. 182.

† Idem, p. 183. The explosion of a sulphureous water at Ballston, by which the peculiarity of the water was destroyed and a sulphureous smell diffused to a considerable distance around, would seem to imply that some of the gases of sulphur are occasionally concerned in generating the power. *American Journal of Science*, Vol. 21, p. 184.

depths and rises freely through crevices in the rock, is rendered probable from its alternately breaking out and disappearing at points somewhat distant to each other. And perhaps the opinion of Berthier may here be applied, namely, that the water of the spring is forced up by the elasticity of the confined gas.

"The phenomena presented at Ballston, so far at least as the evolution of carbonic acid is concerned, are quite analogous to those noticed by Brandes and Kruger in their account of the mineral waters of Piedmont; that the extrication of this gas is by no means limited to the spot from whence the chalybeate springs of that watering place arise, but is observed for some distance round, wherever fissures, natural or artificial, exist. Thus, a cavity having been made by some workmen for quarrying stone, it was found that the air became charged with from thirty-six to forty-eight per cent of carbonic acid, which rose in the cavern to different heights at different times.*

"In general, the occurrence of carbonic acid in these waters is to be ascribed to the existence of large quantities of it held in solution by water at great depths, and therefore under enormous pressure; or by the gas itself being kept by the same agency in a liquid form, until by the removal of the pressure, it assumes the gaseous state, and is thus disengaged.

"It is very difficult to estimate with accuracy the proportion of carbonic acid which these waters contain, as they are continually pervaded by gas, which apparently has no action upon its constituents. Perhaps the best guide in this part of the investigation is to determine the amount of gas necessary to hold the solid carbonates in solution, as they undoubtedly exist in the state of bicarbonates. The following table will exhibit the composition of one of the Ballston waters:

United States Spring.

Specific gravity, 1.00611. Temperature, 50° F. One pint of the water contains,

Carbonate of lime, with a small admixture of oxide of iron,	3.65	grains.
Carbonate of magnesia,	0.72	"
Carbonate of soda,	2.11	"
Sulphate of soda,	0.22	"
Chloride of sodium,	53.12	"
Silica,†	1.00	"
	60.82	grains.

Carbonic acid, 30.50 cubic inches.

"*Low's well*, recently restored, has a composition similar to the preceding, but the amount of saline matter is much less. Its specific gravity is 1.02548, temperature 50° F.

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* Quoted by Professor DAUBENY in his Report on Mineral and Thermal Waters, p. 37.

† "This water probably contains both iodine and bromine; but the quantity upon which I operated was too small to admit of separating them, and determining their relative proportions."

"*Park spring*, situated in rear of the village hotel, has also the same constituents, but the iron is in much larger proportion than in any of the waters in this vicinity."*

Albany Mineral Springs.

The Albany mineral springs issue from the slate rocks of the Hudson slate group. These waters were examined by Dr. Meade,† and by Prof. L. C. Beck.‡ Carbonic acid gas, but rather less in quantity than in the Saratoga and Ballston springs, is contained in this water.§ It is represented as affording perhaps a sufficient supply for four hundred to five hundred visitors daily. The well of this spring was bored for McCulloch's brewery in Albany, in 1826, by Mr. Disbrow. Carburetted hydrogen issued from the well when bored to the depth of two hundred and fifty feet, but the acidulous and saline carbonated water arose from the depth of four hundred and eighty feet in the slate rocks of the Hudson river group. "The boring was continued about six hundred feet through the slate rock, and the flow of carbonated water and inflammable gas continued. The obtaining of fresh water being therefore considered hopeless, a tube was sunk to prevent the admixture of the carburetted hydrogen with the mineral water, and an apparatus constructed for raising a supply of the latter.

"Subsequently, Mr. McCulloch commenced boring a few rods from this place, when, at about the same depth, the vein of mineral water was again struck. It was also accompanied by the inflammable gas, as in the former case. And to add to the interest of the locality, it was, moreover, found, that at the depth of about thirty feet from the surface, a vein of water was crossed which was highly charged with sulphuretted hydrogen gas. We have then in the same slate formation, though at different depths, sulphuretted hydrogen, carburetted hydrogen and carbonic acid gases, abundantly evolved.

"Another curious fact noticed at the locality now under consideration was, that when the pump in the present mineral garden was put in operation, the level of the water in the other well was soon reduced, and it was at length rendered entirely valueless. It may hence be inferred, that there is here a subterranean vein of mineral water; and from the general similarity in its composition to that of the springs of Saratoga and Ballston, it is not improbable that this vein is of considerable extent. Nor would it be at all surprising if carbonated water should be found by boring to a sufficient depth at any place in the range from Albany to Saratoga, where its discovery should be thought of sufficient importance to warrant the necessary expenditure.

"The occurrence of carbonic acid in all these waters, has been ascribed with some plausibility to the reciprocal action and decomposition of the sulphuret of iron and carbonate of lime, contained in the strata of argillite, in which they exist. But if this view is correct, it is not

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* Prof. L. C. Beck's Report on the Geological Survey of N. Y. for 1838, pp. 50, 52.

† Silliman's Journal, XIII. pp. 145, 146. (Dr. W. Meade.)

‡ New-York Medical and Physical Journal, VI. p. 92.

§ Eaton. Silliman's Journal, XV. p. 23.

easy to account for the absence of sulphate of lime, a salt so generally found in mineral springs, and which would, by this supposed process, be abundantly formed. And it leaves still unaccounted for the singular fact, that in the same rock formation different gases are given out at different depths, and appear to be, as far as their origin is concerned, entirely independent of each other. Thus at the Albany spring, sulphuretted hydrogen rises from about thirty feet below the surface, and when a tube is sunk below this, the water contains no admixture of this gas; again at the depth of about four hundred feet, the carburetted hydrogen appears, and lastly, the carbonated water. We must, therefore, refer the production of these gases to more general, and probably more effective agencies.

"It may be proper to state, as it may throw some light upon this interesting subject, that at the Albany spring a tube is sunk into the boring about a hundred feet, and to it is attached a pump for raising the water into a cistern. When the pump has been worked for some time, the sulphur water sinks below the surface of the ground, and again appears when the pumping has ceased. After the mineral water is discharged from the cistern, and the pressure is thus relieved, the inflammable gas flows out. It burns with a reddish white flame, blue at the base. Neither this gas nor the water contain the least portion of sulphuretted hydrogen.

"Composition of the Albany mineral water.* In one pint. Specific gravity at 60° F. 1.00900. Temperature 51° to 52°.

Chloride of sodium,	63.00	grains.
Carbonate of soda,	5.00	"
Carbonate of lime,	4.00	"
Carbonate of magnesia,	2.00	"
Carbonate of iron with a little silica,	1.00	"
	75.00	"

Carbonic acid, 28 cubic inches."†

The temperature of this water is from 51° to 52° of Fahrenheit's thermometer at all seasons of the year, and its specific gravity 1.01. "The taste of the water is purely saline, somewhat pungent, and by no means disagreeable; but those who are best acquainted with it, think it by no means so stimulating and pungent as the Congress spring"‡ at Saratoga. "It has no chalybeate taste."‡ "As to the gas which ascends through the tube, and has been described as inflammable, it appears to be hydrogen or carburetted hydrogen, similar to the gas which is so frequently observed to accompany the saline springs in the State of New-York, but which passes through the water without giving it any sensible qualities. When

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* "The portion of this water which I analyzed, was obtained from the boring, soon after its mineral character was first noticed. The amount of carbonate of iron obtained from it was not, as I have since learned, all chemically combined. I have accordingly made the proper correction."

† Prof. L. C. Beck. New-York Geological Report for 1838: Assembly document, No. 200, pp. 153, 154.

‡ Silliman's Journal, XIII. pp. 145, 146. (Dr. W. Meade.)

this water, which is at first so pellucid and clear, is allowed to remain for a few hours in a glass, the gas which is extricated from it adheres in the form of innumerable air bubbles to the inside surface of the glass; in a short time after the water loses its transparency, a thin pellicle appears on its surface which has a slightly iridescent appearance; by degrees the water becomes perfectly opaque, the pellicle falls to the bottom, which, as well as the sides of the glass, is covered with a light brown powder which adheres firmly to it. The water after this recovers its former transparency, but loses its agreeable pungent and acidulous taste, becoming perfectly vapid, and has no other taste but that of a solution of marine salt in water."*

The following table shows the relative proportions of mineral ingredients in the waters of the Albany mineral spring, the Congress spring at Saratoga, and the Public well at Ballston.†

	Congress spring.	Public well at Ballston.	Albany mineral spring.
	GRAINS.	GRAINS.	GRAINS.
Muriate of soda,	51.50	21.00	59.00
Carbonate of lime,	13.75	4.625	4.00
Carbonate of soda,			5.00
Carbonate of magnesia,	8.50	5.625	1.50
Carbonate of iron,			1.00
Muriate of lime,	1.75	1.75	0.50
Muriate of magnesia,	2.50	0.75	
Oxide of iron,	0.25	0.50	
Total solid contents in one pint of water,	78.25	34.25	71.00
Carbonic acid gas in cubic inches,	33.00	30.50	26.00

Reed's Mineral Spring.

This spring is in South-Argyle, Washington county, near the Moses kill. It is an acidulous carbonated water something like the Saratoga waters, but the gas does not escape very abundantly from the fountain. Bubbles of carbonic acid rise from the bottom of the fountain at short intervals, and the water has a pleasant acidulous taste, but it does not sparkle. It is resorted to by the people around, and many ride there from Saratoga to drink the water for a change.. It is a pleasant acidulous water. It is used by people in the vicinity for raising their dough preparatory to baking it, no yeast being required. The gas is slowly extricated from the water used in wetting the flour, and raises the dough as light as a sponge. The spring rises from a fissure in limestone near its junction with slate rocks, which are metamorphic, or belong to the Taconic division of rocks.

* Meade in Silliman's Journal, XIII. pp. 146, 147. † Ib. p. 156.

Gaseous and Thermal Springs.

Those gaseous springs that contain large quantities of mineral matter in solution, have been considered under the heads of chalybeate, hepatic and acidulous springs. There is still another class in which the mineral qualities of the water are not striking, but the water contains gas which is continually bubbling up from the bottom of the fountain, and which, in the First Geological District, is mostly nitrogen, mixed in some instances with some carbonic acid and oxygen. A considerable number of these springs have been observed, and some of them during the progress of the geological survey. Their geological situation is on or near the junction of limestone with a talcy slate, which is considered as an altered rock; and both these rocks may, in many places, be considered metamorphic. They are all adjacent to faults in the strata, or where the rocks are much deranged in position. Some of the springs are thermal, and perhaps all of them would prove to be so by a careful measurement of their temperatures. Some of them deposit tufa, but most of them are as pure as common spring water, and are employed for domestic uses. Professor Eaton states that the springs through which nitrogen gas rises, contain muriate of lime in solution.*

The range of these springs, as far as has been observed in the eastern part of the State of New-York, is from near the Vermont line in the township of Hoosick, Rensselaer county, by Lebanon Springs, to near Stony point in Rockland county. Those of Virginia, and perhaps intermediate ones, (if I have correctly understood the Geologists of Virginia and Pennsylvania, Professors W. B. & H. D. Rodgers,) may be considered as on the same great axis of disturbance. It is probable that observers may find similar springs in Vermont, Massachusetts and New-York, along the continuation of this line of disturbance, which is near the line between New-York, Massachusetts and Vermont, with a breadth of several miles (including the east part of several counties in New-York), as far as Poultney and Hampton, whence it extends into Vermont. The thermal springs at Bath, Virginia, and still farther south, have nearly the same geological relations as those of New-York, and are on the same or parallel axes of upheaving action.

Hoosick Gaseous Springs.

These springs are numerous in an area of about one hundred acres. They rise through the gravel beds of the drift deposits. No rock in place was seen in the immediate vicinity, but the roof slate stratum ranges west of them within a mile, and this rock is believed to be uniformly skirted at a distance of one to two miles on the east by a stratum of limestone; and it is probable that the rock, at some depth below the soil at these springs, is limestone of the character of that at Lebanon springs.† The flow of water is copious, and the gas rises in abundance. It is mostly nitrogen, as has been shown by Professors Lewis C. Beck and Amos

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* Eaton. Geological Survey of Rensselaer county, p. 30.

† Prof. Eaton long ago supposed these springs to be derived from the limestone. (Vide Silliman's Journal, XV. p. 234.)

Eaton.* The flow of water is so copious that it is applied to milling, by being conducted in troughs from some of the springs. There is no reason to suppose that the gas does not rise as abundantly through the gravel in the region around as where the water flows, and where it manifests itself by bubbling up through the fountains.

These springs, if thermal, are so in a very slight degree. The water was a cool refreshing drink at the time of my visit, on a warm day in July. They were described by Professors A. Eaton and L. C. Beck in 1822.†

A similar spring rises near the road between Hoosick and Williamstown.

New-Lebanon Gaseous and Thermal Springs.

The New-Lebanon spring is well known, and has often been described.‡ It is situated in the northeast part of the township of New-Lebanon, Columbia county, in a mountainous but highly cultivated and densely populated country for a mountain region, and is a place of resort in the warm season for the healthful invigorating mountain air, the medicinal qualities of its waters, and the agreeable society there assembled. The spring is copious, delivering sixteen barrels of water per minute, of the temperature of 73° of Fahrenheit's thermometer, while the temperature of the other springs around is 52°.§ The gas rises in groups of bubbles at intervals of a few seconds; and as the pool is about six feet deep, bubbles are seen rising through some part of the water almost continually. The water is quite tasteless. Its specific gravity is scarcely above that of distilled water, as it holds only a minute portion of saline matter in solution. The following is the composition, according to the analysis of Dr. Meade, of a pint of the water.

Chloride of calcium,	0.25 grains.
Chloride of sodium,	0.44 "
Carbonate of lime,	0.19 "
Sulphate of lime,	0.37 "
	1.25 grains.

"Bubbles of air continually rise through the crevices of the rock at the bottom of this spring, which, ascending rapidly through the water, occasion an incessant agitation, and appear to break on the surface without being at all absorbed by the water. This air is given out in the proportion of about five cubic inches from a pint of the water; and it consists, according

* Eaton. Silliman's Journal, Vol. 15, p. 234.

† Eaton and Beck's Survey of Rensselaer County, p. 29; Eaton's Canal Rocks, 1824, p. 60; L. C. Beck, N. Y. Geological Report for 1838, p. 48.

‡ These waters were analyzed first by Dr. Meade, and afterwards by Prof. L. C. Beck, who is now the Mineralogist and Analyst of the Geological Survey, and his report will contain the mineral composition of all the mineral waters of any celebrity in the State.

§ Eaton. Silliman's Journal, Vol. 15, p. 234.

to the experiments of Prof. Daubeny, of Oxford, now on a visit to this country, who kindly furnished me the results, of 89.4 parts of nitrogen and 10.6 parts of oxygen in the hundred. This is equal to nearly fifty parts atmospheric air, and fifty parts pure nitrogen, in the hundred. Prof. Daubeny could not detect any carbonic acid in the gaseous matter given out by this spring.

"So large is the quantity of water at the Lebanon springs, that advantage has been taken of it, and of the elevation of the ground, not only to supply all the baths, but to turn two or three mills erected within a short distance; these mills are kept in action during the severity of the winter."*

The water issues from the bottom of the gravel beds of the drift, at or near the junction of the limestone with a talcy slate of the Taconic division of rocks. The limestone itself is talcose beween its laminæ. There are traces of a fault, and of much derangement of the strata in the immediate neighborhood.

Similar springs of less volume break out in the vicinity in many places. One is in the ravine a short distance east of the hotels. Another is on Mr. McNaughton's farm in New-Lebanon, between Lebanon springs and the Shaker village, and emits bubbles of nitrogen gas. Another issues from a fissure of the limestone, on the east side of the limestone ledge between New-Lebanon springs and Stephentown. These two springs never freeze, and were observed by Prof. Briggs.

Northeast Gas Spring.

Another gas spring issues on Mr. Isaac Smith's farm, one mile southeast of Judge Bockee's in Northeast, Dutchess county. Mr. Bockee informed me of this spring. I had no opportunity of examining it, and do not know its *exact* geological relations, farther than it is near the limestone, and on the great axis of disturbance before alluded to as that on which the gaseous and thermal springs of the eastern counties of New-York are situated. Gas is said to bubble up through the fountain. Its temperature had not been measured, but it never freezes.

Amenia Gas Spring.

This rises in the bed of a small stream about a quarter of a mile from Ameniaville towards Poughkeepsie; and at another place near, by the road-side, where the ground was covered by water, the constant rise of bubbles of gas was observed for some time. These localities were in the valley west of Amenia, and the gas issued from the gravel beds over or near the junction of the talcy slate with the limestone, and between the Amenia ore beds of limonite, and those at a place called the Squabble-hole ore beds.

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* Prof. L. C. Beck, N. Y. Geol. Rep. 1838, p. 47.

Haverstraw Gas Spring.

This is in the township of Haverstraw, Rockland county, about two and a half miles southwest from Stony point, by the side of the road leading from Caldwell's landing to Haverstraw, on the land of Mr. Alexander Walden. It is a copious spring, a small brook flowing from it, and bubbles of gas are continually rising from different parts of the fountain. The water is used for domestic purposes; and if it be thermal, it is very slightly above the mean temperature of the place. It issues from near the junction of the limestone with a talcy slate of the Taconic division of rocks, (which range reaches the Hudson river from the north at Blue Rock point, at the mouth of Peekskill creek, where the post-road bridge crosses that stream; and on the right bank of the Hudson, it reäppears at a short distance north of Tompkins' lime quarries, between Caldwell's landing and Stony point.) Granitic rocks are near, both east and west; and the talcose slate and limestone both disappear in a short distance to the south of the fountain, under the red sandstone formation of Rockland county.

The *cause* of the evolution of *nitrogen gas* is not known. The theory of Longchamps has been adduced by Prof. Eaton as being a plausible one. M. Longchamps maintains that "the oxygen and nitrogen of the air unite and form nitric acid, when in contact with calcareous substances which are sufficiently porous, and under the influence of a due proportion of heat and moisture. As the sparry limerock is often found porous, and of a spongy texture, it may cause the supposed union of oxygen and nitrogen of the air, which comes in contact with it at a considerable depth under the detritus. Here the temperature of the water may be suitable for the operation. If nitric acid is produced in this manner, the following may be taken for the result, allowing for fractions: Nitric acid consists of 35.1 of nitrogen to 100 of oxygen; atmospheric air consists of 376.2 nitrogen to 100 of oxygen; therefore every 100 of oxygen consumed in the production of nitric acid from atmospheric air, would produce 341.8 of unmixed nitrogen gas; consequently about $\frac{10}{11}$ of the nitrogen gas of the air thus decomposed would issue unmixed from the earth."* If this theory be true, some trace of nitric acid, in some form of combination, might be expected to be observed in the waters, if they flow from where the decomposition is effected; and it is not apparent how atmospheric air in such quantities should be carried deep into the earth, even if such changes could there be effected in its composition. These objections might be urged, and had much weight until the following facts were considered, viz: 1. Water falling in cascades or into deep pits in the ground, carries much air with it; so that if the aperture of entrance into a cavern in which it may fall be narrow, or nearly filled by the descending current, the air can not return; but if the outlet of the cave be open, it will form a *blowing cave*, that is, one with a current of air rushing from it; or if its outlet be under water, the air will issue with the water from its outlet, or escape through the fissures of the rock. 2. Nitrate of lime, we know, is formed in abundance in almost all limestone caves, unless they be very wet. 3. Caves are very common in limestone

* Eaton. Silliman's Journal, Vol. 15, pp. 234, 235.

districts. These facts, which are well known, led me to think more favorably of the theory of M. Longchamps as applied to our nitrogen springs.

The following facts may also aid in explaining the evolution of nitrogen, and of carbonic acid, from some of the nitrogen gaseous springs: 1. As far as my observation has gone, the nitrogen springs of eastern New-York are at or near the junction of limestone with a talcose slaty rock, that is in some instances perhaps a metamorphic rock. 2. Professor Hitchcock* has observed in Massachusetts, and I have observed the same fact in many places in the eastern counties of New-York, that the rocks at the junction of the limestone and talcose slate are loaded with carbon, and frequently also with pyrites.† Should atmospheric air come in contact with these substances by natural means, as by caves or by fissures in the rock, which are not filled with water, a high temperature, or the decomposition of pyrites, might cause the oxidation of the carbon, of the pyrites, or of both, and a consequent evolution of nitrogen and perhaps of carbonic acid.

Springs, Wells, &c.

The springs of Long island are numerous, and present some phenomena worthy of consideration. Around the heads of the bays and reënterings of the coast along the north shore of Long island, copious springs break out very little above tide-water level. In some instances they boil up through the sand and gravel, so as to form a brook at once; in others, several springs break out at the foot of the bank, and uniting their waters, form a stream. The numerous mills and manufactories on the shores of many of the reënterings of the northern coast of Long island, and which have no apparent streams communicating with their ponds to renew the supply of water, attract the attention of most observers. The water of these springs is very pure, in consequence of its having been filtered through beds of nearly pure siliceous sand and gravel. It is thrown out at the level of tide water, or at a higher level, where there are strata impermeable to it. Some of the most remarkable of these springs which are applied to manufacturing purposes, are about Hempstead harbor, at the head of Little-neck bay, at the head of Coldspring harbor, and the southwest part of Oysterbay harbor.

In most parts of Long island, water is not found in quantity, and is not permanent except at about the level of the ocean, in consequence of the porous nature of the strata.

In some places there are local deposits of clay and loam interstratified, which are basin-shaped, and contain the water. These are more abundant in the hilly regions than in the plains. Springs are as abundant and copious on the south side of the island as on the north, but they break out at some distance from the shore, in consequence of the land declining almost insensibly from the hills. The great plain of Long island extends from the base of the hills south to the ocean, descending but a few feet to a mile. On Hempstead plains the wells are dug from sixty to one hundred and twenty feet deep, through beds of gravel and sand, before

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* Professor Hitchcock's Geology of Massachusetts, 1841, pp. 581, 583, 584.

† Mather's Geological Report of New-York for 1838, pp. 88, 96, 130.

water is reached, which is a little above the level of the ocean. The wells gradually decrease in depth thence to the shore. On most of the farms in the interior, artificial means are resorted to, to procure a supply of water for cattle and other farm stock. A basin-shaped excavation is made in the soil, and puddled with clay, and into this the surface waters are conducted during rains. They are called *watering holes*, and are a striking feature of the farming economy of the island.

6. Caves, Subterranean Streams, Natural Springs and Limestone Springs.

Caves.

Caves are not uncommon in the limestone regions of the First Geological District; but none, except those of Schoharie county, have been found so extensive as a few of those of Kentucky, Missouri, and some other States. All that I have examined seem to have been fissures in the limestone, the masses of which have been slightly shifted in position, perhaps, in some instances, by subterranean causes; but the cavities of the caves seem to have been principally formed by the solvent power of water, which gradually dissolved and transported away the carbonate of lime to where it found an outlet as a spring upon the surface of the earth. Almost all limestone caves (and nearly all caves are found in limestone) contain either a stream or pool of water, connected with a spring on the surface; or if they are dry, a careful examination will generally demonstrate that they have been formed by running or standing water, which has dissolved away the rock. Limestone caves may, in fact, be considered as the canals through which subterranean streams or rills either flow now, or have done so in times past.

The caves of some parts of the world contain great numbers of the bones of various animals; others have been inhabited by man in a savage state, and show traces of his arts. Nothing of the kind has been discovered in any of the caves of the First Geological District, if we except the skeleton of a fox, which was discovered in Ball's cave, Schoharie county, by Messrs. Gebhard and son and Mr. Bonny, which seemed to have fallen into the cave, and was unable to escape. The bat (*Vespertilio*) assembles in immense numbers in our caves, to pass the winter.

Some caves have a current of air passing out of them, and might perhaps be termed *blowing caves*, though not comparable with the Blowing cave of Virginia, described by Mr. Jefferson. This seems to be caused by the water falling in a cascade in a narrow space or fissure, carrying air along with it, which must necessarily find an outlet at some opening of the cave. The cave at the village of Clarksville in Bethlehem, Albany county, had a current of air passing out of its mouth at the time I explored it, so strong as to make it difficult to enter it with a lighted candle. This cave has water at a distance of one hundred or two hundred yards from its mouth; and although no water flows from its *mouth*, a large limestone spring issues near the creek, one hundred or two hundred yards from the cave, and is believed to be connected with the water of the cave. Small objects that would remain suspended in water, and that were left in the water of the cave, are stated to have come out from the spring. If this

be true, the evidence of the subterranean communication is unquestionable. Some parts of this cave give very good evidences of the solvent power of water, in the rounded arches ; and the stream probably once flowed from the present mouth of the cave.

There are two other caves in Bethlehem, Albany county, not far from Clarksville, and others in Knox township, but I have not explored them. They are all in the limestone of the Helderberg division of rocks.

The *Spook hole*, near Barnegat, Dutchess county, is a small cave in limestone ; and is said to have so much carbonic acid gas in it, as to make it dangerous to enter without precaution. Lights burned well at the time of my visit. I saw nothing of particular interest. It is about half a mile southeast of Barnegat, and fifty to seventy rods from the Hudson river.

Ball's cave, in Schoharie, about two miles northeast from the court-house, is one of the most interesting that has been found in New-York. It was discovered and explored ten or twelve years ago, by the Messrs. Gebhards and Bonny of Schoharie. For a sketch of it by Mr. Bonny, vide Plate 32. The spaces are in some parts very large, in others very small, as in almost all caves. A stream of water flows through the cave, and there are several small cascades. A boat is kept for the purposes of exploration. The gentlemen who have explored the cave, have given a description of it which was published in the papers of the day. The drawing on Plate 32 will afford all the necessary information. The cave is chiefly remarkable for its extent and beautiful stalactites and stalagmites.

Another large cave has been discovered a few miles northwest of Schoharie, the past summer ; and from the reports and newspaper descriptions, it is probably very extensive ; perhaps as extensive, if such reports be true in all their particulars, as any cave described, except the Mammoth cave in Kentucky.

All these caves, except the Spook hole, are in the limestone of the Helderberg division of rocks, and the lower part of this division is very cavernous. Many interesting caves will doubtless be discovered in those rocks. They were not sought while exploring, and not often inquired for.

There are two small caves in Orange county, Cornwall township, near Round pond, about four and a half miles southwest of West-Point. One was described* as discovered by the sinking down of the ground; the roof of the cave sparkling with the brilliant crystals of spinelle, mica, augite, hornblende, etc. in white crystalline limestone. It is now filled up at its mouth, so as to be inaccessible. The other is called the *Bear hole*, and has probably been a den for these animals. It is situated about one-quarter of a mile west-southwest of Round pond, in the same kind of limestone as the preceding, but in which augite and hornblende form a large portion of the mass. The weathered surface is warty, and has scarcely the aspect of limestone to an unpractised eye. The cave is small, with a circular mouth, scarcely more than large enough for a good sized bear to enter. It would be, and probably has been, a fine winter retreat for those animals.

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* Vide page 36 of this volume.

Subterranean Streams.

These are not uncommon in limestone regions. All rocks near the surface of the earth are intersected by fissures; and into these, the surface waters necessarily find their way, and remain, unless they communicate with the surface of the earth, or a porous soil at a lower level, so as to form springs. In limestone rocks, these fissures become wider in consequence of the solvent action of the water, if it flows through them; and the waters of many of these fissures uniting, have a common outlet, and thus form small or large springs. Sometimes many square miles are thus drained by one spring, and a large stream sufficient for mills, and sometimes for navigation, flows from a single fountain. In limestone regions, springs and streams are less numerous on the surface, than where other rock formations predominate, because the waters mostly flow beneath the surface through the fissures of the rocks, but the springs are copious. Streams in such districts sometimes disappear by flowing into the fissures or caverns, and rise again at a greater or less distance as large springs. These are called *subterranean streams*. Streams thus pass under mountains and hills by natural tunnels. Extensive caverns are thus formed by subterranean streams; and as they become very broad, the rock is sometimes insufficient to support the superincumbent weight, and it sinks in from the surface of the earth, forming *sink-holes* and valleys; and if the sunken space be large, the stream enters at one extremity, and disappears at the other. If they are not large, they are called *sinking springs*.

Natural bridges cover short canals of subterranean streams, where the rock that once covered them has nearly all fallen into the caverns below, and left the stream open to the heavens in a deep ravine, except the small portion which remains to form the bridge.

Limestone Springs.

In Rockland county, a limestone spring has been already mentioned as a gaseous spring.*

In Columbia county, the New-Lebanon springs have also been mentioned † under the same head of Gaseous springs.

The city of Hudson is supplied with water from a limestone spring, on the northwest base of Becraft's mountain. Another spring emerges from the eastern base, and the water was warm when it was examined in the summer season. It tasted like brook water, and is supposed to be the outlet of a small brook that sinks into the fissures of the limestone, in a sink-hole on the top of the mountain.

Near the line of Canaan township, a small stream sinks near the limestone, and reäppears at a distance of a quarter of a mile, on the land of Mr. Lord.

Cold spring, southwest of Stessing mountain in Dutchess county, flows from the base of a limestone ridge. A brook flows from it large enough to carry a mill. It is generally reputed

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* Vide page 107 of this volume.

† Vide page 105.

to be the subterranean outlet of a small lake at the base of Mount Stessing, which has no visible outlet.

The Clove spring, as it is called, in Union-Vale, is supposed to discharge from twenty to thirty barrels of water per minute. The water is very limpid.

Another occurs at low water mark on the bank of the Hudson, a half or three-fourths of a mile north of Barnegat. Another flows from the side of the post-road, a quarter of a mile north of the crossing of the Caspar kill. Another, on Judge Bockee's farm, in Northeast, delivers about twenty cubic feet per minute. The water is very clear, and uniform in temperature through the year.

In Pine-Plains are several large springs. Two are located on Mr. Walter Reynolds' farm, about three miles east of Pine-Plains. Both of them are, in fact, subterranean streams, which sink into the earth and reäppear. The larger stream disappears in a sink-hole in the base of the hill, on the north side of the road from Pine-Plains to Pulver's corners, and reäppears as a large spring boiling up through sand about a quarter of a mile southwest of the place of its disappearance. The road crosses the subterranean stream. There is a sink-hole on the line between these places, where the earth sunk in a few years ago. Another stream vanishes and reäppears twice, south of the above, and a line of sink-holes indicates the line of the subterranean stream. One of them sunk a few years since, carrying a cow and a tree. The tree still lives, but its limbs and top only can be seen at a little distance. The cow, being unable to climb out of the sunken ground, starved to death.

The Sharon springs, which may be considered as limestone springs, have already been mentioned under the head of Sulphur springs. Many others of common limestone water break out from the bottom of the same ravine, one hundred to three hundred yards farther up the valley. Such springs are very numerous in many places along the line of outcrop of the lower beds of the Helderberg system of rocks. Some near Grosvenorville in Carlisle, may be mentioned.

In the eastern part of Bern, Albany county, a stream sinks on the high grounds of the Helderberg, and is supposed to issue again in Thomson's pond, nearly a mile distant.

In Greene county, in New-Baltimore, about two miles west of the Hudson, and three miles southwest of New-Baltimore, is a sinking spring. It rises by the road-side, and sinks at the distance of a few rods at the base of a cliff of limestone, where there is a fault in the strata.

The north fork of the Coxsackie creek in Greene county, sinks in the bottom of the valley near the turnpike gate between Coxsackie and Greenville, and reäppears at the distance of two hundred to three hundred yards, at a much lower level, in the bottom of a deep ravine, in the water-lime series of the Helderberg division of rocks. The south fork of this stream also sinks and passes through a hill, according to Burr's map, but I did not see it.

Many copious limestone springs break out from the base of a high mural escarpment of the water-lime series, and other limestones of the Helderberg division of rocks, between Catskill and Saugerties, within a mile of the Hudson river. A mill is situated on one of them, and the water of others might be economized. Some of them probably sink in the hills farther

back from the river, and may be subterranean streams, as they have been defined,* but no examination was made.

In Ulster county, a sinking spring, called the *O-pack-oke spring*, (an Indian name,) is on the top of Shawangunk mountain, opposite Napanock. I did not see it. It is probably in the Shawangunk grit, and sinks in its fissures.

In Rochester, Ulster county, the stream which flows from the mountains on the northwest, and crosses the road from High falls to Rochester, about four or five miles from the former place, sinks into the crevices of the limestone on the right of the road, and reäppears in the low grounds between the road and Rondout river; but when the stream is high, it flows across the road, and during the freshet of the winter of 1838, washed away the bridge.

In Orange county, in New-Windsor, the water from the outlet of Little pond sinks into a cavern in the limestone. At the distance of three quarters of a mile, a stream, supposed to be the same, emerges from the ground. "At times the stream can be heard beneath the ground, thirty or forty rods before it bursts out at the surface."*

A natural bridge spans the stream that flows into the southwest end of Popelo's pond in Monroe, Orange county. The rock is the white crystalline limestone, resting on hornblende rock on one side, and on granite, it is supposed, on the other, though the rock is concealed by the soil. It is used as a bridge, and "one might cross it without being aware, unless the noise of the brook aroused his attention. The breadth of this bridge across the stream is fifty feet, and its length up and down the stream seventy-five or eighty feet."† The water, at the time of Dr. Horton's visit, filled the cavity, so that he could not see through it; but in times of drought, people pass through it.

7. Sulphur and Carburetted Hydrogen.

Native sulphur has been found in few places in the First Geological District; and in all the localities that have been observed in the survey, its presence in an uncombined state is the result of alluvial causes.

Sulphur is deposited from some of the sulphur springs at Sharon, Schoharie county. At some springs it is white, and perhaps a hydrate; at others it is yellow or grey, and sometimes dark colored. The quantity deposited is not very great, but the earthy matter around some of them contains a large proportion of sulphur, and the sticks, moss, grass, etc. are encrusted with it.

In Phillipstown, along the shore of the Hudson, south of and near the point of Gouverneur's cove, about east of Gee's point, where pyrites have decomposed, a grey or bluish grey powder, composed almost entirely of sulphur, is found. Another locality is about one mile east of the above, near the locality of laumonite and stilbite: it is in cavities in quartz, where

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* Dr. W. Horton's Report; 3d Annual Geological Report, N. Y. p. 158. † Ibid. p. 140.

pyrites have decomposed. Another locality has been described near West-Point,* which is understood to be near Fort Putnam. I have not seen it there as native sulphur.

Should the supply of sulphur from foreign countries cease from any cause, so as to raise the price of that article, the resources within the limits of our country could supply any demand. Beds and veins of pyrites abound in the State of New-York, from which sulphur may easily be obtained. Some of the localities of pyrites of the first district will be mentioned in the proper place. Sulphur, to the amount of some tons, could be procured from the earth and tufa at the Sharon springs, but not sufficient to justify the expense, except in case of an emergency. Sulphur has been observed in fissures where alum occurs near Catskill, on the Helderberg mountain.†

Carburetted hydrogen is known to issue permanently from but few points in the First Geological District. At the salt well in the valley of Elk creek, three and a half miles from Delhi in Delaware county, bubbles of this gas rise through the salt water continually, and may be inflamed. In Dutchess county, an inflammable gas, very pure, rises from the bottom of a small lake in the township of Northeast.‡ At the mineral springs bored for McCulloch's brewery, carburetted hydrogen is evolved.§

8. Sulphate of Iron.

The sulphate of iron is formed by the oxidation of either the common or the magnetic pyrites, both of which are common in many parts of the First Geological District; and this salt is found effloresing on those rocks in situations partially sheltered from the weather, that contain pyrites susceptible of decomposition.‖ The localities of this salt are very numerous, but few of them promise to be of much importance.

In Dutchess county, it was observed in small quantities effloresing on the mica slate, about two miles southwest of Ameniaville, on the east side of the mountain, near an old excavation that had been made under the expectation of finding coal; also four miles south of Ameniaville, at the south end of Barker's mountain, on mica slate; and about two miles south of Poughkeepsie, on the shore of the Hudson, where an excavation and boring had been made in search of coal in the black slate of the Hudson river group of rocks. At all these localities, the bisulphuret of iron was disseminated through the rock.

In Putnam county, many localities of sulphate of iron were observed.

1. An old mine hole in hornblendic rock, a quarter of a mile east of Luddington's corners in Kent, six miles north of Putnam court-house. Copperas effloresces, and causes this rock to crumble to sand. The excavation, which is small, is on the west side of the mill-pond.

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* Robinson's Catalogue of American Minerals: Douglass and Webster, p. 145.

† Robinson's Catalogue of Minerals, p. 132. Webster's Catalogue of Minerals, p. 6. Eaton's Geological Survey of Albany county.

‡ Ackerly. Geology of the Hudson. Cleaveland's Mineralogy, p. 483.

§ Prof. L. C. Beck. N. Y. Geological Report, 1838, p. 41.

‖ Some pyrites do not decompose, unless they be chemically or mechanically acted on by some artificial means.

2. In a vein of quartz, about thirty rods east of Dean pond, also in Kent. Several metalliferous minerals are found here and in the vicinity.

3. About one-fourth to a half of a mile southwest of Pine pond in Kent, at the mine of arsenical iron. The ore, which is abundant, and situated in hornblendic gneiss rock, decomposes on the surface, forming sulphate and arseniate of iron. The mine is called the *Silver mine*, and silver is said to have been obtained from the ore. If it contains this metal, Prof. Beck will make it known in his report containing the analyses of the minerals.

4. Another locality was observed about two miles west of the last, half a mile to one mile from Boyd's corners, on the road to Coldspring, near the turn of the road, exposed in digging the road. This was arsenical iron, decomposed on the surface into sulphate and arseniate of iron.

5. At one of the excavations for magnetic iron ore, eight and a half miles from Coldspring in Phillipstown, on the road to Putnam court-house, and half a mile, or perhaps more, northeast from the principal of the Phillips mines, on the same vein, five or six hundred tons of ore have been blasted from the vein. At this locality, the magnetic oxide of iron is so much intermixed with pyrites, that it cannot be used to make iron. In some places in the vein, the pyrites seems to have been a paste in which the grains of magnetic oxide of iron have been disseminated, but it does not generally form more than one-fourth to one-sixth of the mass of that part of the vein. By exposure to the weather, copperas is formed, which effloresces in dry weather, is washed away by the rains, and is successively formed and renewed, until the pyrites is decomposed and the magnetic oxide left nearly pure.

6. It is believed that sulphate of iron might be manufactured at this place for the market. A slight roasting would facilitate the decomposition of the sulphuret.

7. In Patterson, several localities were observed, where pyrites decomposed and formed copperas. One is near Mr. Robinson's farm, four miles northeast of Carmel.

8. Another on the same road to Patterson, and within two or three miles of the village, on the high ground. The gneiss, about one hundred or two hundred yards west from its junction with limestone, contains much pyrites. The metalliferous bed seemed to be five or six feet in thickness in the vertically stratified rock, and sulphate of iron effloresced on the surface.

9. Another locality, about a mile west of Patterson, is in a ridge of gneiss, between strata of limestone. This pyritous gneiss stratum extends a distance, it is supposed, of several miles, and may at some time be used for the manufacture of sulphate of iron.

10. In Southeast, a locality of sulphate of iron was examined on Mr. Jedediah Wood's farm, six miles southeast of Carmel, on the hill west of the Croton river. Pyrites abound in the rock on the eastern brow of the hill, and copperas effloresces on the face of the rocks. Many of the loose masses at and near the foot of the hill are porous, as if once filled with pyrites, which have decomposed and washed away. Excavations have been made in two places where the pyrites abound. Some of the rock crumbles by the disintegrating action of the crystallizing salt. The pyritous stratum was traced along the brow of the hill about two hundred yards. It has long been supposed there was a lead mine in this hill; and perhaps it may not be inappropriate here to mention circumstances that serve to give countenance to that

idea among some people, who still yield implicit faith to the miraculous virtues of the "mineral rod" and magic glass, when used by the favored few who pretend to be gifted with such peculiar powers.

It is stated by various gentlemen of the highest veracity, that a man of high respectability came from Connecticut to the owner of the farm, and informed him that there was a valuable lead mine on his land, which was worked many years before; that it was covered over with planks; that a walnut stick was lying with one end on the planks, and the other mostly decayed near the surface; that the earth had washed over it about four feet deep, (with other circumstances of detail;) and that he could go directly to it. He would make no communication to indicate the locality, until the owner had executed a bond to secure a certain portion of the profits to the informer, who had never been to the locality, but who stated that he was enabled to see it, and go directly to it, by looking at a polished stone as a mirror placed in the crown of his hat, with his face applied to the opening of his hat, to exclude the view of other objects. He seemed a perfectly unassuming quiet man, with a perfect faith in his ability to perform what he stated. Many of the citizens of the vicinity accompanied him in his wanderings, and he finally stopped near the foot of the hill on which we have described the pyrites, and where he directed excavations to find the mine. The walnut stick was found as indicated, except that there were no planks; and no opening, no traces of a mine, or of any ore, could be discovered. He went away, much mortified with his failure.

A few years afterwards, a girl who was reputed to be able to see in a magic glass, or polished stone held in a dark place, was employed to discover the supposed mine, and it was said she had never been in the vicinity before. She looked, and walked to within a few yards of the same spot, drove a stake in the ground, and said the mine was *there*, at a depth of thirty-five feet; but none has been found.

A man who had moved into another part of the country when a boy, returned when old about thirty-five years ago, and stated, that when he was a boy, he had been into a mine in that hill where the lead ore had been dug, and that he had seen the ore. He had endeavored to find the mine, without letting the people know the object of his search.

Hearing these stories, and many believing that there is a lead mine in that hill, led me to make an examination of the locality with as much care as was practicable without excavations. The loose stones on the surface are more or less porous gneiss, with a reddish colour. Both the porosity and color are due to the decomposition of pyrites probably, for I discovered no traces of any metal but iron. These appearances would very naturally induce the idea of a mine, even without the aid of a *magic glass;* but whether any ore of value occurs *there*, is a subject for investigation. There are no indications that seem to justify the expenditure of capital in search of lead or other metals. The rock near the brow of the hill abounds in pyrites, is nearly vertically stratified, ranges north-northeast and south-southwest, and is intersected by quartz veins (that shew no metallic contents) in a southeast and northwest direction. The great vein of magnetic oxide of iron called the *Simewog vein*, (in consequence of the extensive mines of this ore that have been worked in Simewog hill,) is about one-eighth of a mile west of this locality of pyrites, as is supposed from the great variation

of the compass near Mr. Wood's house. The compass varies in a distance of two rods in an east and west line from 30° to 40°, and the centre is in the north-northeast and south-southwest line of direction of the Simewog vein on Simewog hill. On the north-northwest side of where the vein seems to pass, the compass varies to the east of north 15° to 20°; and on the south-southeast side, it varies as much to the west of north. The stones on the surface where the vein is supposed to pass, contain magnetic oxide of iron disseminated; and some lumps of ore, and masses of manganesian garnet and epidote, were also observed on the same line at this place, and a mine of the magnetic ore has been opened about a mile south-southwest. The white limestone is not far distant on the east from the reputed lead mine.

All the geological circumstances that were observed, and that seem to have a bearing upon this reputed lead mine, have been related. The region is a highly metalliferous one, and it is probable some excavations may have been made here, as in hundreds of other places in the Highlands, by the company of miners that was sent into this country between 1730 and 1750, under the direction of the Baron *Horsenclever;* and that traditions connected with these excavations, aided by some imagination and credulity, have been the basis of many of the reputed silver and lead mines in the Highlands and other parts of New-York.

Many localities might be mentioned in Putnam county, where pyrites decomposes with the formation of the sulphate of iron. The principal that have not been mentioned, are,

1. An old iron mine on Anthony's Nose mountain, about one and a half miles east of Fort Montgomery.
2. An old "silver mine," (but which contains no silver,) on the top of the same mountain, three miles east of Fort Montgomery.
3. On the top of a hill, about one and a half miles east of West-Point.
4. Shore of the Hudson, nearly opposite Buttermilk falls.
5. Shore of the Hudson, several places, nearly opposite West-Point.
6. Shore of the Hudson, several places, between Arden's landing and the landing above.
7. Near the post road, two or three miles east of Arden's landing.

The localities in Putnam county are all in the primary rocks, and nearly all are at or near fractures or uplifts, or localities of more than usual disturbance of the strata.

In Delaware county, sulphate of iron effloresces abundantly on the surface of a pyritous rock, at a "silver mine," as it has been called, on Dry brook, about two miles up the stream from Arkville in Middletown. Another locality is at an old mine hole, where copper has been supposed to exist, on Downe's brook in Colchester. These localities in Delaware county are in the Catskill division of rocks.

In Orange county, 1, at an old iron mine on the farm of Isaac Faurot.
2. Near an old mine hole, one and a half miles north of Capt. Faurot's.
3. Near an old mine hole, one and a quarter miles north of the same place.
4. Near the shore of the Hudson, at Fort Montgomery.

5. At a vein of magnetic oxide of iron and pyrites, within a few rods of the landing at Fort Montgomery.

6. The "Copperas mine," so called, one mile northwest of Fort Montgomery. The sulphate of iron, at this locality, is associated with white augite, limestone and serpentine. It was attempted to be worked by a company in New-York, but was abandoned. There seem two very good reasons why it should not be worked: 1st, because there seems to be an insufficient quantity of the sulphuret of iron for a permanent supply; and 2dly, the carbonate of lime would decompose the sulphate of iron, so that little or none of this salt would be obtained.

7. An old mine hole on Mrs. Kingsley's farm, near the summit of the mountain, one and a half miles southwest of West-Point, and three quarters of a mile west of the Hudson. The hornblende rock contains pyrites, and sulphate of iron effloresces on the rock. According to tradition and common report, a lead mine has been found on this mountain. An old man is said to have supplied himself and neighbors, and the Indians had done the like before his time. Reports and traditions of similar import have been found common in many places in every county that I have explored, except Long, Staten and New-York islands.

8. Sulphate of iron effloresces on the magnetic oxide of iron at the Clove mine, one mile south of Monroe. The ore makes hot short iron, in consequence of the pyrites contained in it. Copperas might perhaps be obtained from this ore with profit.

In Ulster county, slight efflorescences of sulphate of iron were observed on the slate excavated a few years since, to find coal, at the base of the Shawangunk, two miles south of High falls. Some of the pyrites are very beautiful, with a crystalline and plumose arrangement, and often grouped in thin crystalline plates around a centre, like the petals of a flower. The slate is the black glazed slate of the Hudson-river group, with thin scales and glazing of carbonaceous matter.

The grit rock of the Shawangunk two miles south of Rochester, at one locality, was observed loaded with pyrites, which decompose and cause an efflorescence of sulphate of iron. The locality is one-third of a mile south of the Mulekill, and is known as the "Silver mine;" but from which no silver has been, or probably will be obtained. A small excavation has been made in the rock. The pyrites do not seem sufficiently abundant to be important for the manufacture of copperas.

In Albany county, on the east part of the Helderberg mountain, twelve miles from Albany, it effloresces in some quantity.*

In Saratoga county, Dr. Steel has described the sulphate of iron as efflorescing on the transition rocks near Hadley's falls.†

Sulphate of iron is stated to occur near Catskill in Greene county, with calcspar, quartz and sulphate of lead,‡

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* Eaton. Silliman's Journal, Vol. 15, p. 243.

† Steel's Report on Survey of Saratoga county; Robinson's Catalogue, p. 131.

‡ Pierce. Silliman's Journal, Vol. 5, p. 266.

It has been described as occurring in the bed of a stream, two miles east of Durham meeting-house in Greene county, in "coarse slate" filled with vegetable impressions.*

9. Orpiment, and Arseniate of Iron.

Two localities of arseniate have already been mentioned under the head of Sulphate of iron, one at the arsenic mine commonly called the "Silver mine," near Pine pond, in Kent, Putnam county; and the other about a half to one mile from Boyd's corners in Kent, on the road to Coldspring. This locality may not be found again, as it has been covered over in making the road. The arsenical sulphuret of iron was encrusted with a green arseniate of iron, that, when heated with a blowpipe in the deoxidizing flame, gave abundant white, garlic fumes.

The arsenic mine, at the time of my visit, had been recently cleared out, after having been filled with rubbish and water for more than half a century, and the timbers and walls of the mine were incrusted with a yellow sulphuret of arsenic.

Orpiment was also found by Dr. W. Horton, in the arsenical sulphuret of iron at the locality near Amity in Warwick, Orange county.

10. Bog Ore, and Wad.

In Columbia county, bog iron ore occurs in the low grounds in the valley of the Kline kill, three or four miles east of Kinderhook, on Mr. Peter Gardenier's land. It forms a layer of about eight inches thick, under the soil of the meadow. Mr. G. thinks it extensive. The ore is more or less mixed with gravel, but some of it is of good quality. Bog ore is said to occur in the meadows near the Sulphur springs, in the north part of Claverack. It is also found on the farm of Daniel Falls, and on several of the adjacent farms, in a tract of meadow land. It is supposed to be in too small quantities for extensive use. Some of the ore has been smelted at Kemble's furnace at Coldspring, in Putnam county.

Iron ore, probably bog ore, is said to exist in Chatham, east of Groat's corners, on Mr. Burgess' farm.

Rev. Mr. Woodbridge, of Austerlitz, informed me of a deposit of bog ore, one and a half miles from that place, on the farm of Mr. Asa Calkins.

In Dutchess county, bog ore is said to occur in a meadow two miles west of Pine-Plains. At Poquaick, in Beekman, bog ore is also stated to be found.

In Westchester county, bog ore was seen on Judge Kinney's farm, one and a half miles south of Sing-Sing. It was about eight inches thick, but it seemed to occupy an area of only a few square rods, and in an economical point of view is scarcely worth notice. As a mineral, it is well characterized, and makes beautiful cabinet specimens.

Red Ochre and *Red Chalk* occur on H. I. Cruger's farm, in Cortlandtown. It is presumed to be abundant from the appearances at the locality. It has been opened a little, by persons

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* Robinson's Catalogue of American Minerals, p. 130.

who wished to obtain small quantities of these materials. Specimens are deposited in the State Collection.*

In Delaware county, near the village of Delhi, bog ore was observed in some quantity, on the lands of Mr. Titus and Mr. Sherwood. Bog ore was also observed on the flats of the Delaware, on land of Mr. Bela Frost, two and a half miles from Delhi, on the road to Bloomville. Dr. Henry Marshall, of Kortright, informed me of a locality of bog iron ore on the land of Mr. Rich, near Roseville, opposite the mouth of Betty's brook; the ore is said to be abundant. A bed of iron ore was examined near the Delaware, in the township of Tompkins, four miles above Cannonsville. Bog ore occurs on the flats at Deposite, on the Delaware.

In Sullivan county, shot ore was observed, but not abundantly, between Monticello and Forestburgh; also, shot and solid bog ore, on Mr. Hamilton's farm, two and a half miles southwest of Monticello. At both these localities, the ore contained black oxide of manganese, sufficient to give it a black color.

Bog ore is said to have been ploughed up on the flats of the Walkill, near Paltz, Ulster county. The locality has not been explored, and the quantity is not known.

In Albany and Saratoga counties, the localities of bog iron ore are numerous. It is there formed, as in New-Jersey, by the filtering of the rain water, which holds some carbonic acid in solution, and dissolves oxide of iron in the tertiary sands. The water then emerges in springs, and flows into the swamps and depressions, where the oxide of iron is deposited by the evaporation of the water, and the escape of the carbonic acid that held it in solution. Bog ore has been described in Guilderland,† Watervliet and Bethlehem‡ in Albany county, and on the plains between Saratoga and Ballston in Saratoga county, where a forge was supplied for some years with this ore, and which made from fifty to seventy tons of iron per annum.§

On the island of New-York, bog iron ore is stated to exist in large beds, and to contain the oxide of manganese.‖

In Suffolk county, in the bay two or three miles east of Riverhead, bog iron ore has been formed in a solid layer several inches thick. The locality is commonly called *Iron point*. It is not an ore that can be used, as it contains much sand; and in some places is a brownish red sandstone, with limonite for its cement.

In Washington county, bog iron ore is said to have been found two miles southeast of the village of Whitehall. Another locality is a mile and a half south of Comstock's landing. It is here on upland, and mixed with oxide of manganese.

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* Red Ochre and Red Chalk ought not to be described here, being peroxides of iron; but it is the most convenient place to mention their occurrence and locality. They are near the junction of the white limestone and granitic rocks, probably over the limestone.

† Silliman's Journal, Vol. 5, p. 270; Webster's Catalogue, p. 6; and Eaton's Geol. Survey of Albany county.

‡ Eaton's Geol. Survey of Albany county; and Webster's Catalogue, p. 6.

§ Steel. Robinson's Catalogue of Minerals, p. 149.

‖ Pierce and Torrey. Cleaveland's Mineralogy, p. 613.

Wad (*earthy oxide of manganese*).

This alluvial ore is found rather abundantly in a narrow range of country in Columbia county. It is deposited from solution in water, in marshes, like bog ore. It has been found in quantity only in the vicinity of a range of slate, injected with quartz veins, which contain brown spar. Where this spar is decomposed, oxide of manganese remains, which frequently retains the crystalline texture of the spar. This quartz, when exposed to the air, soon loses the brown spar by decomposition, and becomes cellular. The manganese of the wad is supposed to be derived from the brown spar which has been decomposed, and the constituents of which have been transported by water into the low grounds, where the manganese is deposited. Brown spar is composed of the carbonates of lime, magnesia, iron and manganese; and as these bodies are isomorphous, they may replace each other without changing the crystalline form. The brown spar of this range of rock seems to contain an unusually large portion of manganese.

A locality of this ore was discoverd some years since, on Mr. Gott's farm in Austerlitz. It was examined by Prof. Merrick. The ore is found in a marsh, and deposited like bog ore. It has been dug to the depth of five or six feet, but how much deeper it extends is not known. This ore was dug some years since for the New-York market, and sold there at twenty dollars per ton; but in consequence of the small profit derived, the owner abandoned the business. The bed of ore is reported to be extensive. Mr. Gott's grandfather discovered this ore bed about fifty years ago, but supposed it to be iron ore. A light seen near this spot is said to have led to its discovery. A bed of it is said to have been found one mile south of the above, on the farm of Mr. Judson Park.

Mr. Merrick found oxide of manganese or wad about two miles east of Green river, at the outlet of a marsh, near an excavation made for silver ore, but from which little silver will probably be obtained. Many similar localities of wad are reported to exist in this vicinity, and in the northeast part of Austerlitz.

A locality of wad was examined on David Parsons' farm, three-quarters of a mile south of Canaan centre. It was seen at the outlet of a small swamp, and had a depth of from six to eighteen inches. The swamp has an area of perhaps three or four acres, and is probably underlaid by a bed of this ore of manganese, which has been deposited like bog ore.

A bed of wad, or earthy oxide of manganese, has been found on the farm of Joseph Goodsell, in Hillsdale. Mr. Calvin Prescot dug fifty tons of this ore several years ago, and sold it for twenty dollars per ton in New-York.

Another locality was examined, half a mile east of Mr. Goodsell's of Hillsdale. It is of inferior quality.

Oxide of manganese is said to have been found near Ancram lead mine, Columbia county; and on the island of New-York, in pebbles; also near Troy, N. Y.*

* Pierce and Torrey. Cleaveland's Mineralogy, p. 673; and Robinson's Catalogue of Minerals, p. 114.

Boulders and pebbles of the kind alluded to in the above references, are scattered over every township in the valley of the Hudson, to Long and Staten islands. They seem to have been derived from Columbia county, and the continuation of the same rock in Massachusetts and Vermont; and they contain the *pulverulent earthy oxide of manganese*, that has remained in the cavities of the slate and quartz, where the brown spar has been decomposed. The *wad* has been deposited in low grounds, and at the outlets of swamps, and is more or less mixed with bog ore.

It is important that localities of the oxide of manganese should be discovered, from which that mineral may be procured and used in the manufacture of bleaching powder, of glass, etc. The Bennington mines have ceased to supply the demands of commerce, and most of that now used is imported from Germany. Perhaps some of the localities in Austerlitz and Hillsdale may be employed. The manufacturers who use this material in their workshops and factories, could soon ascertain if they could use it with advantage.

11. Carbonate of Copper.

The carbonate of copper has been discovered only in minute quantities in the First Geological District, and the localities observed may be found in the Mineralogical Report by Prof. L. C. Beck.

12. Alluvial Sandstones and Conglomerates.

These are mostly formed by the cementing action of the oxide of iron, and the carbonate of lime, which are deposited from water in the interstices of the grains of sand and gravel, in unconsolidated beds of these materials. The rocks thus formed by the action of present causes are not extensive, and are found in but few places. The filtering of clay in suspension in water, is another cause tending to form solid aggregates; but they have little firmness, yielding readily to the action of water.

At Broad-meadow point, called also Iron point, two or three miles east of Riverhead in Suffolk county, is a recent sandstone in thick solid masses. In some places it is mostly composed of the oxide of iron, and may be called *bog ore*. Generally it is a sandstone, the grains of which are cemented by a large proportion of oxide of iron.

A similar recent sandstone may be seen in the tertiary sand cliffs between Roanoke point and Mattituck inlet, on the north coast of Long island.

Nodular masses of iron pyrites, in one of the gravel and pebble beds of the tertiary on Long island, are common, and by their decomposition form brown hematite. This envelopes the surrounding bodies, which serve as nuclei, and cements them together into solid rocky masses of sandstone and conglomerate. When nodules of clay or of decomposing rock are thus enveloped, geodes are formed, some of which contain loose sand, others lumps of clay, and others are mostly filled with water. All these facts may be seen, illustrated at the high cliff of tertiary on the northeast side of Lloyd's neck, in Huntington, on Long island. Two of the hollow geodes that were filled with water, and found at this place, may be seen in the

State Museum at Albany, and others that were filled with sand, decomposing pebbles, etc. The geodes and the conglomerate formed as above stated, were confined to a stratum not more than one foot thick, and about thirty or forty feet above the tide-water level. Boulders and pebbles of this same ferruginous conglomerate are found abundantly in the more recent drift of Long island and New-Jersey.

At West-Point, the gravel beds of the drift deposits are aggregated into a solid conglomerate, by the deposition of carbonate of lime. This substance invests every pebble and gravel stone with a white or yellowish incrustation; and these crusts uniting, cement the whole into solid masses. Dogtooth spar is sometimes found crystallized in the cavities of this conglomerate, on the shore of the Hudson, a quarter of a mile north of Washington valley, and one and a quarter from West-Point. The drift beds, composed of gravel, pebbles and boulders, are here, in places, cemented; although on casual inspection they might be considered loose. Large masses were seen on the shore, composed of these aggregated pebbles; and on striking those of the cliff above, they were found to be solidified. Another locality is just above the stone culvert across the ravine, on the road from the wharf at West-Point to the plain.

This formation of alluvial rock does not seem to extend far from the surface of the exposed cliff, and is, in part at least, due to the evaporation of water containing the carbonate of lime in solution, which leaves the carbonate investing those objects from which the water has been evaporated.

II. QUATERNARY DIVISION.

This division embraces, in the First district, the clay, sand and gravel beds of the valleys of the Hudson and its tributaries; the valleys of Lake Champlain, and the streams that flow into it; and the more recent clay and sand deposits of Long, Staten and New-York Islands. Some boulders and drift deposits overlie this formation; but the main drift deposit, that is usually called *diluvion*, *erratic block group*, *boulder system*, etc., *underlies* this formation, and will be discussed in its proper place.

This formation consists of three principal members, viz. sand, grey or buff-colored clay, and blue clay; the sand forming the upper, and the blue clay the lower member of this division. (Vide Pl. 4, figs. 1, 2; Pl. 27, figs. 4, 5, 6, 7, 8, 9; and Pl. 39, figs. 5, 6.) No fossil remains are known to have been found in this formation in the First Geological District, except the leaves of a small plant that were discovered in the blue clay in Albany, in the rear of the Medical College, by Dr. J. Eights. These leaves are brownish, but not decomposed,

being still flexible. The continuation of these beds of clay and sand to the lower part of Lake Champlain, abounds in fossils. They have been examined and described by Prof. EMMONS, the Geologist of the Second District,* and are almost identical, it is said, with those now existing on our seacoast. Among them are a sanguinolaria, saxicava, modiola, mytilus, balanus, and some undetermined bones.†

This formation has been deposited since the erosive action that has caused most of the scratches and smooth surfaces of the rocks, and it is believed to be very extensive in our country, though it has not been described, except locally, where it has been classed with the alluvial, drift, or tertiary deposits. Its general distribution in the valleys of the Hudson and Lake Champlain, and the islands at the southern extremity of this valley, have been already alluded to. Dr. Emmons has described the same in the valley of the St. Lawrence, and a similar formation exists around the lakes of the upper part of that valley, and is extensively distributed in Ohio, Pennsylvania, Michigan, and probably in both Upper and Lower Canada. The same formation, it is believed, as that of the Champlain and Hudson valley, is found in almost all the reënterings of the coast of New-England, and in the valleys of the principal streams, as the Connecticut, Thames,‡ Housatonic, Pawcatuck, Blackstone, Charles, Merrimac, and along the coasts of Maine.§ It is also described in Delaware,‖ and occurs extensively in the Middle and Southern States. It is not a very thick deposit, generally not exceeding one hundred feet; and on Lake Champlain, according to Prof. Emmons, it averages about twenty-five feet, and its upper level reaches two hundred feet above the lake, or two hundred and ninety-three feet above tide water.¶ In the valley of the Connecticut, its thickness is supposed not to exceed one hundred to one hundred and fifty feet;** and in the valley of the Thames and its tributaries, to be even less, generally not exceeding fifty feet.‡ In the valley of the Hudson, it attains a greater thickness than I have seen in other places, being in some instances more than two hundred feet, and attains an elevation of three hundred feet near the Hudson river, and perhaps still more above tide water towards the heads of the tributary streams on the flanks of the main valley.

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* Geological Report of New-York, 1837, p. 120.

† Idem, 1838, p. 236.—The following notice of fossils found at Brooklyn, is from the Albany Journal of June 10, 1842. If the description be correct, they are alluvial; and if the roots and peat be much below the level of tide water, would be an evidence of subsidence. I have not seen the locality, and the roots and peat may have been covered to that depth by the wash from the hills, or in filling marshes in grading for streets, making docks, etc.

"FOSSILS. We are told that in the excavations now making in the Atlantic dock at South-Brooklyn, at the depth of twenty feet, a good many roots of trees have been found, evidently in the position in which they grew; and still lower down, a bed of peat."

‡ MATHER on the Geology of Windham and New-London counties, Conn., 1834, p. 31.

§ Hayden's Geological Essays: Cleaveland, pp. 67, 105; Jackson's Geol. Report, 1838, p. 95; Ib. 1837, p. 19.

‖ BOOTH on the Geology of Delaware, 1841, pp. 94, 106.

¶ EMMONS. Geological Report of New-York, 1838, pp. 233, 234.

** Stated to exceed one hundred feet: Silliman's Journal, Vol. 9, p. 29.

The various facts collected in the First Geological District, and inferences from those facts, having reference to this formation, will be related under the following heads, viz.

(*a*). External and chemical characters of its various members.
(*b*). Topographical and agricultural characters.
(*c*). Range, extent, elevation, thickness, and terraces.
(*d*). Economical applications, and mineral contents.
(*e*). Phenomena of water and springs; formation of valleys, slides, faults and wrinkling of the strata.
(*f*). Direction and strength of currents engaged in depositing the different members, and the condition of this part of the earth's surface at the quaternary period.

(*a*). *External characters.*

This formation is composed of three, and in some places of four distinct members, viz. gravel, sand, grey or buff-colored clay, and blue clay. The blue clay rests on a bed of gravel, boulders, hardpan, or on the underlying rock *in place*. The sand and gravel are mostly siliceous, but contain some feldspar, mica, magnetic iron-sand, garnet sand and epidote. The sand on the surface is nearly white, or slightly buff-colored, in consequence of the rain and surface waters having gradually dissolved out the oxide of iron, and transported it to the depressions and swamps, where it has accumulated to form bog iron ore. Where water oozes through the sand in contact with air, the sand is usually stained with the hydrated peroxide of iron (limonite). The causes of the solution and deposition of the oxide of iron have already been explained under the alluvial deposits. The sands and gravel, at a little depth below the surface, are striped, and show the direction and force of the currents from which they were deposited; and by means of the materials of which they are composed, we can, in some instances, ascertain from whence the materials were derived. The usual color of the sand has been mentioned, but opposite New-Haven, and on the west part of Long island, some beds of sand and clay are red, or brownish red, derived from the redsandstone. Concretions of sand, cemented sometimes by calcareous matter, and sometimes by oxide of iron and oxide of manganese, are found in these beds; and others of a tubular form, and cemented, it is said, by a partial fusion, where lightning has struck the earth.

The sandy calcareous concretions, sometimes like a bunch of grapes, and other imitative forms, have been occasionally found around Newburgh bay above the Highlands. Some of these were in the Cabinet of the Lyceum of Natural History of West-Point. Those cemented by oxide of manganese were found by myself, near the brick-yards in the sand-banks overlying the clay beds on West neck in Huntington, Long island, and at the localities of figures 10 and 13, Plate 4. Specimens are preserved, and are in the State museum in the Old State Hall, Albany. It is possible that the sand beds on West neck just alluded to, may belong to the tertiary. The evidence thus far obtained is not sufficient to decide the question.

Lumps of white clay were frequently seen imbedded in the sands of the south part of Long island, along the route of the Long-Island railroad, where the excavations had exposed them, in Jamaica, Hempstead and Oysterbay townships.

Some boulders were observed on and among the sands of this formation, near the railroad from Albany to Schenectady; but they were not examined minutely, and perhaps belong to the subjacent drift deposits, which may here emerge through the sands and clays of this formation.

In some localities, the sand and clay alternate in thin layers, as at Montauk point; where the upper portion of the cliff is composed of alternating layers of these substances, from a line to an inch thick; while the mass below is composed of loam and clay, intermixed with crusts, concretions and geodes of limonite. (Vide Plate 4, fig. 2). The figure referred to is not correctly explained on the plate. The masses at that locality are,

1. Soil and sand;
2. Sand and clay in thin layers;
3. Loam and clay with iron crusts, etc.;
4. Hardpan of drift, cemented by clay, to the ocean level.

Springs flow from the junction of 3 and 4.

The gravel and pebble beds of the quaternary formation of the Hudson valley are composed of washed fragments of all the various rocks in the vicinity, in such directions that currents flowing from a northwardly course would sweep them down the neighboring valleys.

The grey or buff-colored clay of the quaternary division is usually separated from the overlying sand and gravel beds, by a perfectly defined surface; but in some instances loam intervenes, or clay and sand alternate in thin layers between the main masses. In the valley of Lake Champlain and the Hudson, the upper clay bed is almost always grey or buff, striped with slightly varied colors, very uniform in its appearance and chemical composition, containing carbonate of lime sufficient to effervesce with acids, and to justify Professor Eaton's name of *marly clay*. The blue clay is also as well marked and uniform in its characters, through the extensive district referred to, as the grey clay, and the division between them is usually a well defined surface. This clay also contains lime, and its blue color seems due to its having been formed from the dark-colored slates and limestones of that region. The upper clays and sands of Long island, and even those of Staten island, and the lower part of the Hudson below Sing-Sing, which were mostly derived from other rocks than those above Sing-Sing, have a different color and composition, though apparently of equivalent age.*

Dr. Samuel L. Mitchill mentioned the clay beds of this series in his Mineralogical History of New-York, in his report as Commissioner of the Society for promoting agriculture, arts and manufactures, in the year 1800. He says, "The flat between the basaltic rocks and Stony point at Haverstraw appears to be wholly underlaid by argillaceous strata, which, as their edges appear along the shore, are not yet hardened enough to withstand the impression of the walker's foot. Much of the level country between Redhook and Greenbush is evidently

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* The clay beds in the valley of the Schoharie creek have the same characters as those of the Hudson river, while those of the Delaware and Susquehannah are entirely different.

bottomed on a stratum of clay. The tract between Albany and Schenectady, has a stiff and thick layer of clay beneath. The same remark applies to the space lying for some miles beyond the Mohawk river towards the Ballston springs, and to the great collections of similar earthy matter lying westward along the flat country between the upper falls" (Little falls now) "and Fort Stanwix" (now Utica).*

(*b*). *Topographical and agricultural characters.*

The general topographical character of this formation is that of slightly undulating or nearly level plains, like those near Albany, Saratoga, and the south part of Long island in Queens and Kings counties. Near the large streams, as the Hudson and Mohawk, they are frequently intersected by deep ravines down to the subjacent rock.

In some places, this formation rises by a steep bank or terrace directly from the Hudson, as around Newburgh bay above the Highlands; at the brick-yards near Breakneck mountain, at the foot of Bull hill, and at the foot of Butter hill in the Highlands; at the foot of the Dunderberg mountain, and between Peekskill and Verplanck's point in Peekskill bay; at Grassy point, Haverstraw, Teller's point, and along the shore between Teller's and Verplanck's points around Haverstraw bay; at Tarrytown, Nyack, and at various places around Tappan bay; at Athens, Coxsackie, the shore below Catskill, and many other places.

More frequently this formation lies at a higher level along the banks of the Hudson, with the subjacent rocks exposed to the height of fifty to one hundred feet, or covered only by the soil resulting from their decomposition, or by the drift deposit; while at a little distance from the river, a steep terrace of the quaternary rises and extends back nearly level, or rises by another terrace which extends back until it meets the higher grounds of a different formation, occupying the valleys and reënterings as water does along a coast.

The agricultural character varies much, according to the predominance of the sandy or clayey materials of this formation. *Where the sand predominates*, and has some depth over the subjacent clay, the soil is generally clothed with a stunted forest of small pines or shrub oaks; or where there is no forest, the sand is drifted by the winds, and accumulates in ridges of hillocks, wherever fences, bushes, forests, or other objects obstruct the wind. This may be seen on the sand-plains of Saratoga and Albany counties, and in the sand-plains and hills of the central part of Suffolk county.†

The sand-plains make good lands when properly manured and tilled, but many thousand acres are almost drifting sands like the deserts and sand-dunes on the sea-coast; and many thousand acres more would be in the same condition, if its surface was not sheltered from the

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* Medical Repository, Vol. 3, p. 436.

† Many other localities might be mentioned, but a few only will be adduced, as on the southwest part of Staten island; on some of the sand-hills near Brooklyn, L. I., where the whole contour and form of the hills are changing. (FINCH. *Silliman's Journal*, Vol. 7, p. 42.) Jacob's hill northwest of Mattituck on Long island, was once higher than Cooper's hill, which lies on the east; but the sand has drifted off so much that it is now lower.

wind, and the particles bound together by the fibrous rootlets of the small pines and scrub oaks.* Such lands, on the sand-plains of Albany county, have been redeemed from their natural sterility, by the labors and example of JESSE BUEL, a man who has done as much to benefit the agricultural interests, and to elevate agriculture as an art, a science, and an honorable occupation, as any other individual in our country. Capital may be profitably invested in such improvements, where the vicinity of good markets will justify the expense. Such lands also, in the vicinity of New-York, in Kings and Queens counties, have been brought under good cultivation, by highly manuring them, aided by a judicious rotation of crops. The soils of some of those plains are so much altered by the decomposed vegetable and animal matter derived from the crops and manure, and from the large quantities of ashes and street mud brought from New-York and spread upon them, that they would scarcely be recognized, did not the excavations made for cellars, wells, the railroad, etc. show the sands below the depth of the plough.

The clay soils were originally covered with heavy pine timber (*Pinus strobus*), and with some oaks. They are well adapted to grass, and are extensively cropped with oats and other grains; but those lands composed of loam, derived from the intermixture of the clay and sand by natural or artificial means, or of sand with the clay sub-soil so near the surface as to retain sufficient moisture for the plants without making it swampy, are the most productive. This class constitutes a very large portion of the quaternary deposits of the Hudson and Champlain valley, and much of those of Long and Staten islands.

Clay forms the sub-soil, or exists at a greater depth below the gravel and sand beds which form the extensive plains along the elevated banks of the Hudson river, and in the valleys of its tributary streams. There are two kinds, the blue and the grey clay. They are almost uniformly associated, the blue lying below the other. Their line of junction is generally very distinctly marked. They are horizontally stratified, except where slides or some local disturbance has recently taken place. These clays are very fine, and free from grit. The grey is striped with numerous thin layers, which vary in color. Mr. Finch notices the occurrences of pyrites and fossil wood in these clays, but I have not observed them.

Both the grey and blue clays are calcareous, effervescing when moistened by an acid, and have been mistaken for marl. They are, in fact, a kind of marl, and *marly clay* would be a proper name for them. They may be used with great advantage on sandy or light loamy soils. The clay would be a permanent benefit to those soils, while the calcareous ingredient would afford lime which is considered as necessary in soils on which wheat is cultivated.

It is believed that the marly clays and clayey marls of the Hudson valley would be a valuable fertilizer of the soils of Long island; but experience must determine whether most benefit can be derived, at the same expense, by using clay and lime, or these marls, to dress the soil.

Most of the large villages of the Hudson valley are situated on the quaternary formation, where the early settlements were made, and where the agricultural productiveness *has been greater* with a given amount of labor, and will *continue to be greater* than on the more hilly and

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* This wood is mostly pine, and used for steamboats and locomotive engines.

rocky grounds. Poughkeepsie, Hyde-Park, Rhinebeck, Fishkill, Hudson, Claverack, Kinderhook, Pine-Plains, Troy, Lansingburgh, Scaghticoke, Cambridge, Salem, Granville, Argyle and Fort-Edward, on the left side of the valley of the Hudson; and Paltz, Kingston, Hurley, Saugerties, Catskill, Athens, Coxsackie, Albany, Schenectady, Schoharie, Middleburgh, Ballston and Saratoga on the right side of the valley, are among the principal towns and villages situated on or near this formation.

The gravel beds of this formation occupy a large area in the valleys of Pawlet and Poultney rivers, in the townships of Hampton, Granville and Whitehall; in the valley of the west branch of Wood creek in Fort-Ann; in the valleys of Black creek, White creek, and Batten kill in Salem and Jackson; and in the valleys of the Owl kill and Little White creek in the townships of Cambridge, Jackson and White-Creek in Washington county. This formation of gravel may be seen well developed at Cambridge and Salem in Washington county. It also occupies some space in the valleys of the Hoosick, Wallamsack, Little Hoosick, Tomhannock and Kinderhook creeks in the townships of Hoosick, Petersburgh, Berlin, Pittstown and Stephentown, in Rensselaer county.

The same kind of gravel beds occur in the valleys of Wappinger's and Lebanon creeks, Fishkill and Sprout creeks, Ancram creek, Croton river, and in the valleys of all the larger creeks in the hilly and mountainous regions of the First Geological District. These gravel beds are generally highly productive and good soils, except in the instance that has been mentioned on the Batten kill, where the gravel and pebbles were of granular quartz.

(c). *Range, extent, elevation, thickness and terraces.*

The quaternary division, the subject of this article, has been already alluded to as very extensive, not only in New-York, but in Vermont, Massachusetts,* Connecticut, Rhode-Island,† Maine,‡ Pennsylvania, Ohio, Michigan; and in the valleys of all the main streams in the Western States. It is believed to be the same formation that constitutes the "second and third bottoms," in many of the valleys of the Western and Southern States. Prof. Emmons has described its extent on Lake Champlain and the St. Lawrence river,§ and Prof. Vanuxem in the central part of the State of New-York.‖ This formation is not continuous, but forms patches more or less extensive, through the valley of Lake Champlain and the Hudson river, in the First Geological District. Beginning on the north, the following localities may be mentioned, where patches of this formation occur.

Along the shore of Lake Champlain, from the north line of Putnam southwardly about four miles, is a belt of the quaternary formation, mostly clay; but in some places, sand and gravel

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* Hitchcock's Geological Report of Massachusetts, 1833, pp. 173, 178.

† Jackson's Geological Report of Rhode-Island, 1839, pp. 129, 130.

‡ Jackson's Geological Report of Maine; Cleaveland's Mineralogy; Hayden's Geological Essays.

§ New-York Geological Report, 1837, p. 107; 1838, pp. 233, 239.

‖ Prof. VANUXEM. Final Report on Geology of New-York, pp. 212, 220.

beds are seen. It is not more than a half to three quarters of a mile wide, and is frequently very narrow. Another narrow belt skirts the part of Twelve-mile marsh, that lies between Dresden and South bay of Lake Champlain; and another, the marsh between South bay and the mouth of Poultney river.

Another lies southeast and south of Whitehall, between the Pawlet river and Wood creek.

Another extends from Hampton and West-Poultney on the Poultney river, southwest to Granville, where it spreads into broad plains.

Another commences at Fort-Ann on Wood creek, and extends through the valley of the Champlain canal to Sandy-hill, whence this formation extends towards South bay of Lake George, and up the Hudson to the mountains west of Glen's-Falls; thence southwardly along the base of the mountains, and to Saratoga and Ballston springs; thence by a narrow belt to Schenectady, where it communicates with the same formation that covers so much area in Albany and Schenectady counties. From Sandy-hill, it extends down the Hudson river, with a variable breadth, through the townships of Fort-Edward, Greenwich, Easton, Scaghticoke, Berwick, Greenbush, Schodack, Stuyvesant, Ghent, Claverack, Stockport, Greenport, Livingston, Clermont, Redhook and Rhinebeck. Here the connection of this deposit is interrupted, and does not communicate with those farther down the river.* Branches or arms of

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*Mr. JOHN FINCH, in 1826, described in a general manner the quaternary formations of a part of the Hudson valley, under the name of *tertiary*, and compared it with the tertiary of the London and Paris basins; and but for the fossils of the Champlain valley being *identical with recent species*, and the deposits of the Hudson and Champlain valley being undoubtedly contemporaneous, they would perhaps be classed with the tertiary. Mr. Finch also has mistaken the true position of the drift, which he calls *diluvion*, and which he has confounded with the *upper drift*, or the deposits of gravel and pebble beds that cap the quaternary, though the two are frequently mingled where no clay beds intervene. As Mr. Finch's paper contains local descriptions, some extracts are made.

"Immediately superimposed upon the transition clay slate, are the tertiary strata, consisting of an extensive deposit of clay marl, containing from twelve to fifteen per cent. of carbonate of lime; color blackish blue, bluish grey; sometimes contains iron pyrites and fossil wood;* varies in thickness from ten to sixty or eighty feet. The original deposition was probably of a uniform thickness, and the irregularilies of its surface may have been produced by diluvial torrents."

"Adhesive slate forms large beds in the preceding stratum; color yellowish grey, greyish white; particles of it adhere to the fingers; it occurs in laminæ, varying in thickness from half an inch to six inches; fracture earthy; when dry, conchoidal. Used extensively in the manufacture of bricks."

"Clay sometimes occurs in large beds in the clay marl, or occupies its place; color various."

"Diluvion is the highest of these formations, and is distinguished, as in every part of the earth's surface, by sand and gravel containing detached pebbles of the older rocks."

"At Newburgh, the diluvial strata form numerous rounded eminences, which may be traced to some distance in the country. South of the town, the clay appears at the surface. One mile north, on the shore of the river, is adhesive slate."

"At Fishkill landing, on the opposite shore, the adhesive slate forms a continuous stratum extending near two miles."

"Near Marlborough, the clay marl predominates."

"At Hyde-Park, near the residence of Dr. Allen, the clay marl makes its appearance, about half way down the declivity of the hill; but it may be seen to more advantage on the estate of William Bond, Esq. immediately on the shore of the river, and adjoining the property of Judge Pendleton. When exposed to the action of small torrents of water, the marl assumes various singular forms, and becomes indurated by exposure to the air. These figured marls" (the clay stones

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* This is believed to have originated in mistaking this for another deposit. M.

this formation like bays, are found in the valleys of all the streams that cross it. The other portion of this formation, on the right bank of the Hudson, extends from Pelham in Esopus, to the mouth of the Rondout, by Kingston, Saugerties, Catskill, Athens, Coxsackie, to New-Baltimore; thence northwest by Salem in Bethlehem, along the base of the Helderberg mountains in a very irregular line, lapping around the salient points of the hills, and up the valleys, as water occupies an irregular coast, to about two miles west of New-Scotland; thence up the valley of the Norman's kill, to within four miles of Duanesburgh; thence northeastwardly to the Mohawk, along which it extends in a narrow belt above on both banks.

The slate, limestone, and other rocks emerge through the plains of this formation in very numerous places like islands; and in some of the valleys, the connecting parts are so narrow, that they might, without close examination, be supposed to be disconnected; such as those between Saugerties and Catskill, Catskill and Athens, Athens and Coxsackie,* Coxsackie and Coeymans, and Schenectady to Ballston. In many places along the Hudson river where this formation is mentioned, it cannot be seen from the river, in consequence of cliffs, hills and mountains intervening. Below Albany, on the east side of the river, the main mass of these deposits lies back two or three miles from the Hudson, and ranges by Kinderhook, Claverack,

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described in page 82 of this volume) "occur in various other places near the North river, and have been described in the American Journal of Science. The diluvial strata at Hyde-Park, are distinguished as forming a level plain of some extent, on which the village and several gentlemen's country seats are situated. I believe a plain of similar elevation may be traced in many other parts bordering on the Hudson."

"Between Hyde-Park and Rhinebeck, are extensive depositions of clay."

"Albany is built on the clay marl formation, and in this respect resembles London. The ground is traversed by numerous ravines. In the vicinity, the cascades of Arno and Tivoli, and the rapids of Norman's kill, which every one who sees will admire, are caused by the torrents wearing away the higher strata, until they arrive at the solid strata of the transition slate."

"At Greenbush, is an extensive formation of the adhesive slate. Dr. T. R. Beck has deposited specimens in the Cabinet of the Lyceum of Natural History in Albany."

"At Troy, the clay marl is abundant, and contains fossil wood.† The plain above the city, from whence there is a fine view of the falls of the Mohawk, is composed of diluvial debris. The height of this formation is probably the same as at Hyde-Park and Marlborough. The strata in this vicinity have been described by Mr. Eaton, in his Index to the Geology of the Northern States."

"At Schenectady, the same formations are visible; they also form the whole tract of country between that city and Albany."‡

* The range of the main body of the clay and sand beds in Green and Ulster counties, is from a few miles north of Coxsackie, by that village and the landing, up the Coxsackie and down Murderer's creeks, to Athens, thence to Catskill, and thence down the Hudson four or five miles, with a variable breadth, from one hundred yards to two or three miles. It occurs again at Saugerties; ranges by Glasco, near which it leaves the Hudson, and passing among the limestone and slate hills, which are as islands, it ranges by Kingston, Bolton and Eddyville. From Rosendale, it ranges across the northeast point of the Shawangunk mountains, (the grit rock of which disappears beneath it,) south to the Walkill, and a few miles up that stream.

The clay and loam lands of this formation have long been held in high repute, but it is only within a few years that these light and sandy soils have begun to be appreciated. They are easy lands to till, and by means of plastering and clovering, they make soils of the best quality.

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† This fossil wood was found in the alluvion at Troy, where it is abundant. M.

‡ Silliman's Journal, Vol. 10, pp. 227, 229.

Johnstown, Clermont, Redhook, Rhinebeck, &c. Merino mountain, Becraft's mountain, and other high hills, are entirely or mostly surrounded by the quaternary division. Bays of this formation occupy the east side of Huzzy hill, and the valley of Black creek; the valley of the Rondout, to Eddyville; the valley of the Esopus creek, from Kingston by Hurley and Marbletown, to Rochester and Wawarsing, on the Rondout. A large cluster of rocky islands, if we may so term them, emerges through the quaternary, and forms most of the hills of the townships of Northumberland, Saratoga, Stillwater, Halfmoon, Clifton-Park and Malta in Saratoga county; another cluster of these islands extends from Rochester in Ulster county, between the Esopus and the Rondout and Hudson rivers, by Kingston to Saugerties, and thence on by Catskill to New-Baltimore.

The whole of this formation, on the east side of the Champlain and Hudson valley, from Whitehall to Rhinebeck, is interspersed with rocky islands.

Another of the quaternary patches occupies a part of the valleys of White creek and Black creek in Salem, Washington county, and the valley of the Battenkill between Fitch's point and Red bridge in Salem; thence it extends south by Jackson and Cambridge, down the Owlkill, to the Hoosick river; whence it ascends that stream and its main tributaries, the Wallamsack and Little Hoosick, by Hoosick falls and Hoosick corners, towards Bennington, Williamstown and Berlin. One main branch or bay of this formation extends from Cambridge northeast to the south bend of the Battenkill, and extends some two or three miles up that stream. It is probable that the Battenkill once discharged its waters through the valley of the Owlkill, into the Hoosick.

Another of these patches commences in the valley of Kinderhook creek in Stephentown, Rensselaer county, and communicates with that of the Lebanon valley.

Another forms plains in Hillsdale, Copake and Ancram, in the valley of Ancram creek and its tributaries in Columbia county.

Another extends from Pine-Plains down Wappinger's creek, and up some of its tributaries in Dutchess county. The drainage that now finds its outlet through Ancram creek, probably flowed in former times through the valley of Wappinger's creek.

Another occupies a part of the valley of Oblong creek in Northeast and Amenia, in Dutchess county.

Another forms the plains in Dover, and extends south up the valleys of the streams that flow from Pawling into the Ten-mile river in Dutchess county.

Other deposits of similar character with those above described, occur on Fishkill creek and its tributaries, in the townships of Fishkill, Beekman, Lagrange and Unionvale; on Wappinger's creek and its tributaries in Lagrange, Pleasant-Valley, Washington and Clinton; and perhaps this may be connected with the same formation about Poughkeepsie and Hyde-Park, and with the main mass of the quaternary formation of the First district, that was described as probably terminating in the lower part of Rhinebeck.

A small patch of the quaternary occurs on and near the shore of the Hudson, between the mouth of Fishkill creek and the point of Breakneck mountain; another between this mountain and Bull hill; another between Bull hill and Quarry point, which extends southeast and south

by the West-Point foundry, quite narrow, to near Anthony's Nose mountain. Another occurs on the east side of Peekskill bay, one and a half miles south of Peekskill; another at Verplanck's point; another along the bay east of Verplanck's point; another forms Teller's point, which was an island of this formation, now connected with the main land by a marsh of alluvial deposition. Another forms the shore of Haverstraw bay, between Teller's point and the point two miles north.

A small patch occurs at Tarrytown, and others occur in the valleys of all the main streams of Westchester county, the principal of which are Scrub-oak plains in Yorktown, and the plains in Somers and Bedford.

Some other small deposits of this formation occur on the bank of the Hudson, as at Dobb's ferry in Yonkers, and Manhattanville, which are very narrow. The last extends across New-York island to Harlem, where it spreads into plains.

In Rockland county, a deposit of this formation occurs in Clarkstown and Orangetown; another, in Haverstraw, extending from the base of the High Tom (the highest peak of the Palisades), by Haverstraw and Grassy point, to Stony point; and another along the shore at the base of the Dunderberg mountain, near Caldwell's landing.

In Orange county, the quaternary occupies a considerable area between Newburgh and the Highlands, and small patches occur in the Highlands near the shore of the Hudson. One of these is in the valley between Butter hill and the north branch of the Crow's Nest; another, composed mostly of gravel overlying the boulders and coarse drift, but without clay beds, extends from the base of the Crow's Nest mountain, by Washington's valley, to West-Point, where it forms the plain of West-Point. This deposit *may* belong to the drift.

Another deposit of the quaternary exists in Goshen. It has been exposed in draining the Drowned lands; and several patches of it occur in the valley of the Walkill and its tributaries, and in that of Murderer's creek and its branches. Another exists about Port Jervis, Carpenter's point and Cuddebackville, on the Neversink and Basher's kill.

In Ulster county, besides the large deposit already mentioned as extending from Washington county through Saratoga, Albany and Greene into Ulster, are several patches of the quaternary. One is on the shore of the Hudson, south of Marlborough; another north of Marlborough; another near Paltz landing; another extends from Rosendale on the Rondout, across to the Walkill, and up the valley of that stream by Springtown, New-Paltz and Libertyville, and thence in narrow belts up the valleys of the Shawangunk and Walkill rivers.

In Schoharie county, the quaternary deposits occur in the valley of the Schoharie creek, between Esperance and North-Blenheim. At Schoharie, all the members are well characterized.

The sand beds of this formation in the Hudson valley, do not cover extensive areas with loose deep sands that drift, or make the travelling over them tedious, except the sand plains of Albany, Schenectady and Saratoga counties; those about Sandy-hill and Galesville in Washington county; and between Glasco, Kingston, Rosendale and Springtown in Ulster county; and on Long island. The sand is deep and loose along much of the southern shore of the island; along the central part to Riverhead and Canoe place; from Sag-Harbor to

Easthampton; and many other parts too numerous to mention. On Staten island, also, the south and southwest parts are loose sand.

The clay lands of thc same formation occupy the valley of the Champlain canal, to Fort-Edward and Fort-Miller on the Hudson; also a part of Argyle up the valley of the Moses kill, and the west and southwest parts of Easton in Washington county. It also occupies the west part of Scaghticoke, Berwick, Greenbush and Schodack in Rensselaer county; narrow belts near the Hudson, to Fishkill and Newburgh; along the Mohawk in Schenectady county; and in Albany county, belts more or less broad along the Mohawk, and up the valleys of the Norman's kill, Vlamman's creek, and Coeyman's creek. Where the sand occurs, it is uniformly above the clay beds, and generally covers the plains that divide the waters of the creeks and smaller streams.

The thickness and elevation have been already slightly alluded to in the introductory remarks on the quaternary formation. I have no data to give the exact height to which this formation attains, except in a few localities, but it is supposed that it does not, at any point in the Hudson valley, attain an elevation of more than five hundred feet above tide water. The strata are nearly horizontal, or if inclined, the dip is insensible to the eye. It overlies the slates, limestones, grit and other rocks unconformably, except some localities along the western bases of the Helderberg and Kayaderosseras mountains, and on the Mohawk, where the rocks are nearly horizontal.

Mr. Disbrow bored for water for the Water-works Company in 1825, on very high ground in the rear of the Capitol at Albany. He bored one hundred and twenty feet through clay to the hardpan. In another well for the same company in Albany, locality not specified, he bored through twenty feet of clay, sand and gravel, and seventeen feet of hardpan, when water overflowed from the surface at the rate of five gallons per minute. At Boyd and McCulloch's brewery, he began in a well thirty feet deep, which was probably through clay, and twenty feet above tide. The following is the section to the rock:

Clay?.....	30 feet.
Coarse gravel and hardpan,.....	11 "
Black slate.*	

At Hudson, at seventy feet above tide water, the following section was obtained in boring a well, viz:

Clay,.....	144 feet.	} Quaternary.
Sand,.....	40 "	
Hardpan,.....	30 "	} Drift.
Gravel,.....	4 "	
Slate rock, 70 feet.*		

At New-York, a well for the Manhattan Company; level forty feet above tide:

Sand and gravel to granite,.....	40 feet.
Bored into granite,.....	240 "

* Silliman's Journal, Vol. 12, p. 139.

The Stuyvesant meadows in the city of New-York, formerly a salt marsh, with alluvion superposed on the quaternary, is now dyked out, and much of it filled in and graded for streets, and some of it is covered with streets. The three following sections are in this area.

A boring made for the Dry Dock Company at the corner of Avenue D and Tenth-street, gave the following sections :

Made earth filling,	6 feet.	Alluvial.
Marsh mud,	10 "	
Quicksand,	12 "	Quaternary.
Shore sand and gravel,	53 "	
Hardpan,	6 "	Drift.
Coarse gravel,	3 "	
Granite.*		

Another at the corner of Avenue D and Fifth-street :

Made earth filling,	6 feet.	Alluvial.
Marsh mud,	10 "	
Quicksand and gravel,	65 "	Quaternary.
Grey clay,	15 "	
Granite. Water rose within four feet of the surface.*		

Another at the corner of Rivington and Columbia streets :

Well,	20 feet.	Alluvial.
Quicksand,	10 "	
Marsh mud and clay,	20 "	Quaternary.
Grey clay,	10 "	
Granite. Fine water obtained.*		

Another boring was made at the corner of Allen and Hester-streets, New-York :

Well already dug,	40 feet.	
Quicksand, some layers of gravel,	20 "	Quaternary.
Clay,	2 "	
Coarse gravel and sand,	5* "	Drift ?

Another was made in Broad-street, for Mr. Tunis Quick :

Made ground, filling,	4 feet.	
Yellow clay,	6 "	Quaternary.
Gravel and quicksand,	19 "	
Grey clay,	10 "	
Granite. Water rose within 7 feet of the surface.*		

At New-York, (and many other places may be named on Long island and in the Hudson valley,) the quaternary beds of clay, sand and gravel, are covered with deposits like the drift,

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* Silliman's Journal, Vol. 12, p. 141.

composed of coarse gravel, pebbles and boulders. These seem to have been transported by a stronger current rushing from the north through the channels that will be named, to the localities where they are now found.

In the subjoined quotation from Prof. GALE's report to me on the Geology of New-York island, it may be understood that the *diluvium* mentioned by him, in many localities, refers to these upper drift beds overlying the proper quaternary sands and clays.

"The island contains in every part abundant evidence of a current having swept over it from northwest to southeast, both from the grooves and scratches* still visible on the solid rocks of the island itself and its vicinity, and from the materials themselves being traceable to the original rocks whence they have been transported. The southern part of the island contains the largest amount of these materials. In the southeastern extremity of it, usually denominated Corlear's hook, the surface has been graded in some places seventy or even eighty feet below the natural level, and shafts have been sunk seventy-five or eighty feet more without reaching the rock. The diluvium and alluvium together are therefore in this vicinity at least one hundred and fifty feet, the streets having been graded in some places half that depth below the original soil. It is proper to state that the whole of Corlear's hook and its vicinity originally consisted of a series of conical hills of diluvial sand, gravel and pebbles, with masses of all sizes, from pebbles to boulders fifteen or twenty feet in diameter; all of which have been removed and deposited in the neighboring valleys and low grounds. Here were collected, not only the largest quantity, but the greatest variety of rocks that were found in any part of the island.

"We will now enumerate the different depths at which the rock has been reached by borings for water, or for other purposes, in different parts of the island which are covered by alluvium or diluvium. Most of these borings were commenced in this city many years ago by Mr. Levi Disbrow; and the same business is successfully conducted by his son, Mr. John Disbrow, from whom most of the subjoined facts were obtained.

"Commencing at Corlear's hook, we find a shaft was sunk at Mr. James P. Allaire's works, in Cherry-street, about eighty feet through diluvium, stratified sands, clays, or gravel, without reaching the rock. Again to the westward about half a mile, at the foot of Jefferson-street, the rock was reached through ten feet of diluvium, and forty feet of stratified sands, and gravel alternating with clays.

"At Fulton market, a shaft was sunk through fifteen feet of artificial ground; then one hundred and fifteen feet of stratified sands, blue clay and river mud alternating, and the rock was struck at the depth of one hundred and thirty feet.

"At Holt's hotel, a few rods north of the last mentioned place, a shaft was sunk through one hundred and twenty-six feet of strata like those at the market, and the rock reached through a bed of gravel, and the shaft sunk five hundred feet into the rock, which is gneiss

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* The grooves and scratches are believed to be principally due to the action of the *lower* drift deposits, lying below the quaternary sand, gravel and clay beds, and which are frequently partially cemented by clay into what is often called "hardpan." This will be discussed under DRIFT.

with veins of quartz and granite; two hundred feet of the upper part of the bore is a three inch hole, and the remainder two and a half inch. The water obtained from this well was at first tolerably good, and promised to be very serviceable, but since has very much deteriorated, and is now said to be even more saline than that of the neighboring river.

"On the west side of the island, at Washington market, which is on the west side of Washington-street, between Fulton and Vesey-streets, a shaft was sunk ten feet through artificial earth; fifty feet through river mud, containing decayed vegetable matter, sands, clays, etc., in thin alternating strata; ten feet of sands and gravel, when the rock was reached at seventy feet from the surface.

"Again, at the corner of Grand and Wooster-streets, a shaft was sunk forty feet through artificial earth; then twenty feet of mud, clays, and sands highly charged with decaying vegetable matter; then six feet of fine blue clay; and lastly, six feet more of coarse sand and gravel, when good water being obtained, the borings were discontinued at the depth of seventy-two feet from the surface. The depth was considered as at, or at least as very near, the surface of the rock, from the fact that in almost all cases where the rock was reached at great depths through similar strata, it was found covered with a bed of gravel or sands, like that above mentioned.

"In College place, directly north of Columbia College, which is on more elevated ground than the market, the rock was reached at the depth of eighty feet, through twenty feet of diluvium and sixty feet of stratified sand and gravel alternating. If we follow the high range of grounds in a longitudinal direction, as in the neighborhood of Broadway, though we have fewer data from which to judge, yet it is believed that the rock here approaches nearer the surface than in the places above mentioned. This is inferred from the fact that the direction of Broadway corresponds with that of the strike of the strata, and is generally more elevated than the grounds on either side of it; and the contour of the rock follows, it is believed, that of the loose earth which covers it.

"At the old rock well near Trinity church, the shaft was sunk twenty-six feet through diluvial gravel and sands, when the rock was reached, though not penetrated, and good and permanent springs of water obtained. At the City Hall, the shaft was sunk ninety feet to the rock, but is in the district of the Collect (see vertical section, Pl. 3, fig. 1). The celebrated well, corner of Bleecker-street and Broadway, is four hundred and forty-eight feet deep; forty-two feet through stratified sands and gravel, and four hundred and six feet in solid rock, having the usual character of the gneiss of the island. The bore of the shaft is seven inches diameter, and yields one hundred and twenty thousand gallons in twenty-four hours, according to the statement of Mr. D. senior, who made the borings, and who also states that the water rose within thirty feet of the surface.

"The shaft of the city reservoir, in Thirteenth-street, a few feet east of Broadway, is one hundred and thirteen feet deep and seventeen in diameter, with two adits at bottom; one seventy-five, the other one hundred feet long. The rock was reached at about twenty feet.

"In the same street, a few rods west of Broadway, the rock was reached at the depth of about three feet, approaching in one place very near the level of grading. At Sixteenth-

street, corner of Second, Third and Fourth avenues, the rock appears; and the soil, as we go northward, continues to grow thinner and thinner.

"As we approach the East river from any point in the middle of the island, between First and Twentieth-streets, the rock dips down to a depth of ninety to one hundred feet below grading, as evinced in the shafts sunk in this part of the city.

"The diluvium and stratified sand and gravel, it appears, extends on the west side of the island as far as Thirty-first street, and on the east side to Sixteenth-street; and notwithstanding this formation is found in every other section of the island, it is in comparatively small quantities."*

The alluvial meadows and valleys of New-York island, as described by Prof. Gale, cover the quaternary deposits; and some parts of those valleys expose the quaternary, without being covered by alluvion. They are grouped together by him under the name of *alluvium*.

The following extracts from his report, give information on the thickness and extent of the alluvial and quaternary of some parts of the island.

"There are three principal beds or valleys of alluvium that demand particular description. The first, lying in the very centre of the city, includes nearly the whole length of Centre-street with Elm on the west, and Orange and Mulberry-streets on the east, to the neighborhood of Canal-street. This valley was formerly called the Collect, as it was a receptacle for the draining of the adjoining higher grounds. In some portions it was a mere quagmire, and in others a collection of stagnant water fifty or sixty feet deep, and is said by some of the oldest citizens to have had an outlet communicating with the East river along what is now called Roosevelt-street; and another, with the Hudson across the Lispenard meadows, crossing Broadway at what was then called the Stone bridge (now corner of Broadway and Canal-street.) The Lispenard meadows extended from Broadway to the Hudson, and from the vicinity of St. John's church to Spring-street on the north, including the range of Thompson, Laurens and Wooster-streets.

"This first valley being a fresh water alluvion, and a quagmire originally, was of great depth, as has been recently proved by soundings made by Mr. Disbrow, in the place now occupied by the Halls of Justice in Centre-street, between Franklin and Leonard-streets, where iron rods were sunk forty feet through artificial earth, thirty feet through black mud, five to ten feet of blue clay, then a bed of gravel resting on the rock. Still farther south, at the Manhattan water-works, on Centre, between Reade and Duane-streets, seven shafts were sunk thirty feet each in coarse diluvial gravel without reaching the rock. The water supplied by the Manhattan Company is by no means the best in quality, but is used for want of better in culinary operations in a considerable portion of the southern part of the city.

"The black mud brought up from the lower part of the strata of the Collect was as salt as the waters of the river, though very good water was obtained at a higher level on the outskirts of this valley. This fact is generally explained, by considering the water from the gravel

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* Geological Report of New-York, 1839, pp. 184, 187.

beds bordering on the valley as that drained from the surface of higher grounds; while that from lower strata, as from the black mud above mentioned, was derived from the river either directly or indirectly, and being heavier, retained its place at the bottom.

"The second alluvial valley lies on the east side of the island, and includes what was formerly called the Stuyvesant meadows, and all the low ground extending southward to the vicinity of Corlear's hook, or from Twenty-first-street on the north to Delancy-street on the south, and from the river on the east to about half a mile westward; this last boundary varying somewhat in its distance from the river in different portions of it. This region is throughout a salt marsh, and was formerly to a considerable extent covered by the tide at every flow, but is now shut out by dykes and filling in of the streets. The strata composing this alluvion are mostly alternations of sands, clays and mud, and beds of sand or gravel resting on the rock, which last is from ninety to one hundred feet below the grade level surface.

"The following are some of the results of borings made in this alluvial district. At the corner of Fifth-street and Avenue D, a shaft was sunk, which reached the rock at the depth of one hundred and nine feet.

"At the Dry Dock another was sunk, which came in contact with the rock at the depth of one hundred and thirty feet, and penetrated it two hundred feet.

"At the corner of Houston and Lewis-streets, the rock was reached at ninety-four feet. At the corner of Houston and Avenue D, at ninety-six feet, and at the corner of Seventh and Lewis-streets, the rock was reached at ninety-three feet; and at the corner of Seventh-street and Avenue D, it was reached at the depth of one hundred feet. In these borings, it is evident that the rock dips down on the east side of the island to about one hundred feet below the grade level of the streets.

"The third bed of alluvium is that already referred to under the name of the Harlem and Manhattanville valley; the form of which approaches that of a scalene triangle, having the longest side on its southern borders, and extending from the village of Manhattanville on the Hudson to the termination of Ninety-fourth-street on the East river; its shortest side from Manhattanville to the northern limit of Harlem village, near One-hundred-and-thirtieth-street; and the remaining side from the last named point on the north, to the termination of Ninety-fourth-street on the south. The width of the island at this place is about two and a half miles, and the length of the valley east and west the same, while its extent north and south is about two miles. The strata throughout the valley are alternations of sands, loam and gravel, generally in strata, but sometimes in conical hills thrown together in great confusion; and when this is the case, it is gravel and pebbles rather than sand or loam. The gravel and pebbles predominate towards the western portion of the valley; sand and loam in the eastern. Boulders are less abundant in this than in most other portions of the island.

"Comparatively few excavations or borings have been made in this valley; consequently we have fewer data for determining the depth of earth covering the rock. In the northern part of Harlem village, at the corner of Fourth avenue and One-hundred-and-twenty-ninth-street, the rock appears, and has been removed by blasting; and in a number of other places in the vicinity, it approaches the surface or within a few feet of it. Indeed it is inferred that

the whole valley is comparatively shallow, inasmuch as the rock appears from ten to twenty feet above the surface, both to the north and south of the valley, and immediately on its borders.

"The extreme eastern portions, and especially the southeastern parts, are a salt marsh, which, along the borders of Harlem creek, approaches the Third avenue; but as few, if any, excavations have been made in it, little can be said of its geology.

"Besides the above mentioned alluvial beds, others are found in different portions of the island, but they are so inconsiderable as to require no particular description.

"There is, however, a prolongation of the Harlem and Manhattanville valley, which extends northward, and embracing the Eighth avenue, till it strikes the Harlem river at McComb's dam. It consists generally of sand and diluvial loam, and is almost a perfect level. Few boulders are to be seen on its surface, except on its northernmost part, where they are found in great abundance."*

The clay beds at Albany are more than one hundred feet thick in many places; and between that city and Schenectady, sand thirty to fifty feet thick overlies the clay.

At Troy, the gravel and sand beds overlie the clay to a depth of thirty to fifty feet. This may be seen at the south end of the town, where the land-slide of the first of January, 1837, occurred, by which several lives were lost, and some buildings destroyed. The top of these gravel and sand beds is judged to be about one hundred and fifty to one hundred and eighty, possibly two hundred feet above the Hudson; and the thickness must here be at least one hundred and fifty, probably two hundred feet.†

At West-Point, the top of the gravel beds is one hundred and eighty-eight feet above tide-water; and the main terraces of gravel through the Highlands, on both banks of the Hudson, is supposed to be about the same height.

The sand beds in some parts of the southern portion of the island of New-York, are supposed to belong to the quaternary; but in some places the excavations are through drift, and the subjacent tertiary beds, before reaching the gneiss rocks, on which all the superior deposits rest.

At Roanoke point on Long island, and for two or three miles east, the shore is high, and composed of clay and sand of the quaternary above the layer containing the boulders; and beds of sand, and clay of the tertiary era, underlie also this drift deposit.

The terraces of the quaternary are not well developed in the immediate valley of the Hudson, except in some few localities; but in the tributary valleys, which seem to have been

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* Prof. GALE's Report to W. W. Mather, on the Geology of New-York island. Vide New-York Geological Report, 1836, pp. 187, 190.

† Mr. Finch mentions fossil wood as abundant in the clay marl at Troy. (Vide Silliman's Journal, Vol. 10, p. 229.) This is presumed to be derived from Mr. Hale's account of the geology of Troy, in which "logs of wood, and other vegetable substances in a tolerable state of preservation," were stated to be found at about twenty-eight feet below the town; but this is in the alluvion. (Vide Silliman's Journal, Vol. 3, p. 73.)

estuaries, they are more distinct. They are rarely, however, so well characterized as in the valleys of the Connecticut, the Thames, and most of the southern and western rivers.

In Rensselaer county, the sand and clay members of this division are described as alluvion by Prof. Eaton; the clay ranging in a stripe from the south end of the county, nearly parallel to the river, and one or two miles wide, and a quarter to half a mile from the river, as far as Troy. The sandy deposit lies east of the clay and above it, and one or two miles wide.*

"The clay range approaches the river as it proceeds northerly, and forms most of the first hill back from the bank of the river, and it continues pretty uniformly throughout the county. On the river side of these ranges, the soil is mostly gravelly loam or river alluvion. In some places, clay flats are formed. On the eastern side commences the yellow loam, often very gravelly, which forms at the least three-fourths of the soil of the county. In some places, it contains so much clay as to be denominated *clay loam*; in other places, it should be called *upland loam*."† Remarks nearly similar in regard to some of the members of this formation, and to the soils, might be applied to all the counties on the Hudson from the Highlands to Lake Champlain.

(*d.*) *Economical applications.*

The materials forming the different members of the quaternary division are applied very extensively to useful purposes. The clays are used to improve the sandy soils, and make them more loamy; to the glazing of stone ware; to the manufacture of common earthen ware, and of tiles and bricks. The sands are used for casting or moulding sand, sawing marble, moulding bricks, for smoothing and rubbing stones used in lithography, blotting sand, and for making mortar and glass. Most of the localities of sands used in the arts will be discussed under the tertiary. The gravel and pebble beds furnish inexhaustible supplies of hard, smooth, round stones for paving. The drift and tertiary beds also furnish these, and the localities used will be mentioned in another place. The brick manufacture gives employment to a greater number of individuals, and to more capital, perhaps, than all the others. The Albany clay has long been used for glazing stone ware, and is transported to various parts of the country for this purpose. Both the buff colored and blue clays are used for making bricks. Sand in variable proportions is trodden or ground with the clay, so as to give a suitable degree of porosity to the wet brick, that it may not crack in drying or in burning. Some of the clay beds contain thin layers of sand, so that the material requires little or none to be added, as at Cornwall; others require one-third sand, but the sand beds are never far distant, so that the transportation of that material costs little, and very frequently the same bank of earth that yields the clay is capped by beds of sand. Some of these sand banks furnish the fine sand used in moulding bricks. A bank of this sand, on the shore of the Hudson, is valuable, as it sells for twenty-five cents per bushel. The brick-yards are generally sup-

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* Eaton. Geological Survey of Rensselaer County, 1822, p. 25.

† Id. pp. 25, 26.

plied from localities long used. This sand is composed of fine grains of quartz, feldspar, garnet, hornblende and magnetic oxide of iron.

The following tables show about the number of bricks made annually between the years 1836 and 1841, in the different counties, towns, and yards as specified. Where the yards or persons are not specified, the number opposite is set down as the *estimated* number, not that obtained from the yards.

BRICK MANUFACTURE OF THE HUDSON VALLEY.

County.	Town.	Owner.	Year.	Number made annually.	County aggregate.	Grand aggregate.
Schenectady,	Schenectady,	Sundry persons,	1840	1,000,000	1,000,000	
Albany,	Albany,	do do	—	10,000,000	12,000,000	
	Coeymans,	do do	—	2,000,000		
Rensselaer,	Lansingburgh,	do do	—	1,000,000	9,500,000	
	Troy,	do do	—	6,000,000		
	Greenbush,	do do	—	500,000		
	Castleton,	do do	—	1,000,000		
	Schodack,	do do	—	1,000,000		
Saratoga,	Waterford and sundry others,	do do	—	1,000,000	1,000,000	
Washington,	Whitehall and sundry others,	do do	—	1,000,000	1,000,000	
Greene,	Coxsackie,	do do	1839	5,000,000	18,000,000	
	Athens,	do do	—	8,000,000		
	Catskill,	do do	—	5,000,000		
Ulster,	Sundry places,	do do	—	2,500,000	2,500,000	
Schoharie,	do do	do do	—	500,000	500,000	
Putnam,	Phillipstown, foot of Breakneck,	do do	1838	2,000,000	3,200,000	
	Phillipstown, foot of Bull Hill,	do do	—	1,200,000		

Brick Manufacture of the Hudson Valley.

County.	Locality.	Number made annually.	County aggregate.	Grand aggregate.
Westchester, ...	At Carpenter's yard below Peekskill, ...	7,000,000		
	the four yards east of Verplanck's, ...	5,000,000		
	H. I. Crugher's yard, southeast of Verplanck's,	500,000		
	Jesse Wood's yard, 2 miles above Teller's point,	6,000,000		
	Anderson's yard, do do do	2,000,000		
	Frost & Doty's yard, do do do	5,000,000		
	Wager & Hull's yard, half mile do do	2,000,000		
	Hull's yard, half mile above Teller's point, ...	1,500,000		
	Yard on Teller's point, ...	1,500,000		
	James and Samuel Wood's yard at Tarrytown,	5,500,000		
	Appleton's yard, three miles below Sing-Sing, .	500,000		
	Daniel C. Hardin's yard at Sparta,.....	1,200,000		
	Charles Smith's yard at Sing-Sing,.....	500,000		
	Stephen Ford's yard, one mile above Sing-Sing,	500,000	39,700,000	
Rockland, ...	Hodge's yard, Grassy point, they made in 1838,	2,500,000		
	William Holmes' yard, do do do	2,000,000		
	Mumer's yard, do do do	3,500,000		
	Mackay's yard, at Haverstraw, do do	2,500,000		
	Churchill's yard, below Caldwell's Landing, they made in 1838, ...	1,000,000		
	Lent's yard, below Caldwell's Landing, they made in 1838, ...	500,000	12,000,000	
Orange, ...	F. Clark's yard, in Cornwall, in 1838,.....	1,260,000		
	Cronkite's yard, do do say.....	1,500,000		
	W. Stringham's yard, do do	1,000,000		
	N. Audam's yard do do	3,000,000		
	M. L. Sproat's yard, Walkill, do	300,000		
	S. C. Wood's yard, Goshen, do	300,000		
	Norris' yard, Newburgh, do	2,100,000		
	Anderson's yard, Newburgh, do	300,000	9,760,000	
	In 1837.			
Dutchess and Columbia,..	Near foot of Breakneck mountain, Fishkill, 2 near mouth of Fishkill creek, Fishkill, ...	5,000,000		
	4 brick-yards at Stuyvesant,.....	1,750,000		
	1 — between Stockport and Columbiaville,.	100,000		
	1 — Mellen's, Hudson, ...	2,000,000		
	1 — near Mellen's, Hudson,.....	1,000,000		
	1 — near New-Lebanon,.....	50,000		
	— Upper Redhook landing, ...	400,000		
	1 — Walker's, Lower Redhook landing,..	900,000		
	— Staatsburgh, 1½ miles northeast of Mr. Emmett's, ...	1,500,000		
	Several brick-yards east of Poughkeepsie, ...	3,000,000		
	— do do	1,500,000		
	1 brick-yard, Charles Vassar, do stock bricks,*	1,600,000		
	1 — Andrew Underhill, do do	1,000,000		
	1 — Halley, Poughkeepsie, stock bricks,..	800,000		
	1 — near Barnegat, ...	.....		
	Several, sundry places, ...	100,000	20,750,000	130,860,000

The aggregate annual value of the bricks manufactured in the Hudson valley, including the stock bricks, cannot be less than $700,000.

* Stock bricks are worth $20 per thousand; common brick, $5·50.

The brick yard at Tarrytown has been in operation about forty years, and was established by James Wood, the father of the proprietors occupying it in 1838. He is said to have invented and patented the improvement in burning bricks by the use of anthracite.

This method is a great improvement over the former one not only in expense, but in saving time. Four days only are required to burn a kiln, while formerly fourteen to sixteen were necessary, where wood alone was employed, and the expense is reduced about three-fifths. The bricks being somewhat porous, permit the air to penetrate to the particles of anthracite diffused through their substance, and the heat is thus applied just where it is required, and without loss; and the wood is necessary merely to raise the temperature of the bricks to such a point that the anthracite shall begin to burn.

The principle involved in this improvement has been long in use in Europe; and in England their brick earth is required by law to be mixed with a certain proportion of the ashes of stone coal, which always contain much coke or half burnt coal, and which, during the burning, performs the same office as the dust of anthracite, and makes hard burnt bricks. Many improvements have been made in the brick manufacture within a few years, and they are all in use in the brick yards on the Hudson river. The most important are those for grinding the clay, for moulding by machinery, and the one for burning that has already been mentioned. At Carpenter's yard, below Peekskill, the grinding and moulding are effected by steam power. The clay and sand banks along the banks of the Hudson contain the elements of wealth and industry, which will require a great length of time and the most favorable circumstances to exhaust.

The quantity of dust anthracite employed in the Hudson river brick yards, is about three pecks to 1000 bricks, or seventy-five bushels to 100,000 bricks. The kilns generally contain 300,000 to 400,000 bricks, but some are burnt containing 1,000,000. The time formerly required to burn the brick kilns with wood alone, was about thirteen to fourteen days. It took about forty cords of oak wood to 100,000 bricks. With this improved method, they burn their kilns in three to four days, with a consumption of only sixteen cords of wood to 100,000 bricks. Wood is worth five dollars per cord, and dust anthracite costs $0·75 to $1·25 per ton.

The former cost of burning was as follows:

For 100,000:	40 cords wood, at five dollars per cord, ...	$200
	14 days attendance, say	20
		$220

By the improved method, the cost is,

For 100,000:	16 cords wood, at five dollars per cord, ...	$80
	75 bushels dust anthracite, at one dollar per ton, ...	3
	4 days attendance, ...	6
		$89

The expense of burning is thus reduced to less than one-half its former amount, while the time of effecting the burning is reduced to less than one-third.

There are potteries in Canterbury and some other places in Orange county, Ellenville in Ulster county, Poughkeepsie in Dutchess county, and probably other places where they were not seen. Stone ware is the principal article made, and the clay is obtained from South-Amboy and other places in New-Jersey. The glazing is the marly clay of the Hudson valley.

(*e*). *Phenomena of water and springs, formation of valleys, slides, &c.*

The water of the clay beds of the Champlain and Hudson valleys, has been alluded to under the alluvial deposits, when treating of mineral waters, as containing, as a general thing, muriate of lime, and in some places sulphate of magnesia, and in others sulphuretted hydrogen. The water of this formation is generally what is termed *hard*, or has the property of decomposing the *alkaline*, to form an *earthy soap*; separating the acid from the previous combination in the water, and the oil from the soap. The sand and gravel beds, however, often yield an abundance of soft water, nearly pure, or, in some places, slightly chalybeate. The water is universally used for drink, and all domestic uses; and when "*hard*," is made *soft* by the addition of ashes, sal soda, or other substances that will decompose the earthy salts in solution, when it is required for washing.

Springs, Wells, &c.

The springs of Long island are numerous, and present some phenomena worthy of consideration. Around the heads of the bays and reënterings of the coast along the north shore of Long island, copious springs break out very little above tide water level. In some instances, they boil up through the sand and gravel so as to form a brook at once; in others, several springs break out at the foot of the bank, and uniting their waters, form a stream. The numerous mills and manufactories on the shores of many of the reënterings of the northern coast of Long island, and which have no apparent streams communicating with their ponds to renew the supply of water, attract the attention of most observers. The water of these springs is very pure, in consequence of its having been filtered through beds of nearly pure siliceous sand and gravel. It is thrown out at the level of tide water, or at a higher level, where there are strata impermeable to it. Some of the most remarkable of these springs, which are applied to manufacturing purposes, are about Hempstead harbor, at the head of Little Neck bay, at the head of Coldspring harbor, and the southwest part of Oysterbay harbor.

In most parts of Long island, water is not found in quantity, and is not permanent, except at about the level of the ocean, in consequence of the porous nature of the strata.

In some places there are local deposits of clay and loam interstratified, which are basin-shaped, and contain the water. These are more abundant in the hilly regions than in the plains. Springs are as abundant and copious on the south side of the island as on the north;

but they break out at some distance from the shore, in consequence of the land declining almost insensibly from the hills. The great plain of Long island extends from the base of the hills south to the ocean, descending but a few feet to a mile. On Hempstead plains the wells are dug from sixty to one hundred and twenty feet deep, through beds of gravel and sand, before water is reached, which is a little above the level of the ocean. The wells gradually decrease in depth thence to the shore. On most of the farms in the interior, artificial means are are resorted to, to procure a supply of water for cattle and other farm stock. A basin-shaped excavation is made in the soil, and puddled with clay, and into this the surface waters are conducted during rains. They are called *watering holes*, and are a striking feature of the farming economy of the island.

Good fresh water is often obtained on the shore, and on the beaches and spits, by digging down to the level of the adjacent salt water. This fact was communicated to me first by W. H. Sidell, a civil engineer, who had often thus quenched his thirst when surveying the shores and the long sand-spit near Oyster-pond point. This fact should be generally known. Its explanation is obvious. The rain, as it falls, sinks in the sand down to the water level, where it remains. As the tide rises, it rises and falls with it; and as the difference of specific gravity is slight, it will not escape, unless the tide overflow the sand-bar or spit, and in this case it mixes with the salt water.

Good fresh water may generally be expected to be found on beaches, spits and bars, where they are not overflowed by the tide, at the sea level.

Water is found generally in abundance in penetrating the clay beds down to, or through the subjacent drift deposits, before reaching the rock, in the quaternary of the Hudson valley. This is observed as a general fact in digging and boring wells; and frequently the water flows from the surface of the earth, where the boring is through the clay beds, and the surface of the country at no great distance is higher. This is due to there being a head of water in the gravel beds; and the clay beds being impervious, the water can not rise until an opening is made through the clay. The water will then rise, and if restrained by a tube, will rise to the level of its source, or overflow on the surface. Artesian wells are bored through various strata, where water is prevented from rising by their being impervious. Mr. Disbrow has bored a great number of wells, and many of them have overflowed at the surface. The salt marshes of Long island, and the adjacent islands of our coast, may probably have an abundance of good water by boring and tubing the wells. The water will either overflow, or rise to near the surface; but if the sand and gravel beds communicate with the ocean, or with the salt water, the wells may be expected, after a long time, to yield brackish or salt water. Borings have often been made for *artesian wells*, in situations where the geological structure was such that they could not be expected to be successful. New-York island is a good example. The strata there are vertical, or dip at a high angle, so that no water could be expected, except that flowing through the gravel beds in the depressions along the edges of the strata, parallel to the line of bearing. As the island is surrounded, at no great distance from every part of it, by deep channels, and as no portion is much elevated, and

as there are no clay beds or other strata that are impervious to water above the gravel beds, except over small areas, the water could not be expected to rise and overflow *permanently*. The borings for artesian wells are most likely to be successful, where the strata are very slightly inclined, and gradually dip down towards the place of boring, from higher grounds, in at least one direction, with no deep valleys near, that intervene. In such situations, unless the rocks be pervious to water, as open grained sandstones, limestones or other rocks with many open fissures, the borings will generally be successful.

The water beneath great cities becomes contaminated by the various animal matters that filter into the soil, so that no long period has elapsed before it has been found necessary to bring water from a distance by aqueducts, except where it could be obtained to overflow in artesian wells from a great depth. Nearly all the principal cities of Europe, both ancient and modern, were and are supplied by water brought from a distance; and although little more than two centuries have elapsed since the first settlements were made on the Hudson, the water of the wells of several of the cities has become so impure, from saline, animal, and decomposing vegetable infiltrations, that it was not potable, and the inhabitants have obtained water from a distance, actuated by considerations of health and comfort. Albany is supplied with water from the Patroon's creek; Hudson, from a limestone spring on Becraft's mountain; and the city of New-York, from the Croton river, by an aqueduct 32·88 miles in length. The reservoir contains 500,000,000 gallons of water, above the level at which the aqueduct will discharge 35,000,000 gallons per day.* The supply is deemed amply sufficient; as the daily supply will be more than a barrel of water to each individual, if the city contained a million of inhabitants. This is one of the noblest works of ancient or modern times; and although mostly concealed below the surface of the earth, so that the obstacles overcome in its accomplishment can scarcely be appreciated, yet it is constructed in such a manner as to endure for untold ages of time, and to be an honor to the city that authorized it, and to the engineers who have planned and executed the work.†

Valleys are formed in the quaternary deposits, on some parts of Long island, and in many parts of the Hudson valley, by the effects of small streams cutting away the clay and sand beds; by springs undermining beds of these materials, and allowing them to sink; by making quicksands, which flow off and carry the superincumbent materials; or by making clay beds slippery, so that if the beds incline, even in a very slight degree towards lower ground, and a valley, ravine or bank occurs, so that they are not supported in that direction, they slide off.

Small sinuous valleys are frequenly formed by springs flowing from or over quicksand beds. This is well illustrated on the north shore of Long island. At Roanoke point, and in that vicinity north of Riverhead, beds of clay and sand overlie the drift, and the tertiary clays and sand underlie the same deposit. The springs cause the sands to flow, and render the clay beds slippery, so that the cliffs crack off and slide down on the shore, where the finer parts

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* Introduction to the Natural History of New-York, Vol. 1, Part 1, p. 144.

† The cost of the Croton aqueduct is about $12,000,000 (Idem, p. 145.)

are washed away; and the operation is repeated whenever the base of the cliff is not sufficiently supported, and valleys are formed, continually penetrating farther inland along the course of the spring. In these little valleys, the springs wash away a part of the materials, and then more slide down (Vide the wood-cuts on land-slides in this volume, p. 33).

Valleys are widened by the same cause, in places too numerous to mention, in the clay formation of the Hudson valley. Faults of these beds are also thus produced (Vide Plate 31, figures 5 and 8). Wrinkling of the strata is also produced by the same cause, by the lateral forces tending to crush and separate the laminæ, and force them between the yielding saponaceous layers (Vide Plate 31, figures 2, 4, 5, 6, 7).

(*f*). *Direction and strength of currents that deposited the quaternary division, and the condition of this part of the earth's surface at this period.*

The subject of the *direction* of the currents, as indicated by the *laminæ* and *water lines of deposition*, has not been studied with the care it deserves, and no result is offered as obtained by careful induction from many facts; but the *general course of transport* is from the northward. It is believed that when this subject shall have been attentively studied, the directions will be found to be such as would be produced by a general current setting from the north through the valleys that will be named,* modified by tidal currents, and the various irregularities of the forms of the hills, mountains and other obstacles that must, when covered partly or entirely with water, have produced eddy currents in various directions, and depositions varying greatly in their quantities and degrees of fineness.

It is evident from the localities in which the quaternary deposits are situated, that the general contour of the country was, in the main, the same as at present; and that the change of level necessary to bring these formations above the water level, has been in *mass*, without much *relative* change of position.

The larger sand and gravel deposits, as the superior members of the quaternary, have been deposited *at the confluence of great valleys*, through which we may suppose currents to have flowed, and consequent eddies to have been formed, in which matter held in suspension would be precipitated.

EXAMPLES.

1. The Saratoga plains, are at the junction of the upper Hudson valley from the west, and the Champlain valley from the north.
2. The Albany and Schenectady sand plains, are at the junction of the Mohawk and Norman's kill valleys, with the Hudson valley.
3. The Kingston plains, are at the junction of the Esopus creek and Mamakating valley from the southwest, with the Hudson valley.

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* See page 150.]

4. The sand plains between Rosendale and Springtown, are at the junction of the Walkill valley with the Hudson valley.
5. The Newburgh quaternary, extending by New-Windsor and Cornwall to Butler hill, are at the junction of the valleys of Murderer's creek and Smith's clove from the southwest, and some smaller ones, with the Hudson valley.
6. The Fishkill plains, are at the junction of the valley of that stream with the Hudson valley; and the principal extensions are opposite the valleys from the north, and opposite the corresponding valleys to the south, as opposite Fishkill village, Hopewell, &c.
7. Kinderhook plains, those of Clermont and all along the east bank of the Hudson, may be referred to the junctions of the valleys of the various streams from the east and northeast with the Hudson valley; and all are connected, as we see the alluvia in the Hudson from Wappinger's creek to the Highlands, where the tide sweeps the alluvia of various streams along so as to unite them.
8. The sand plains between Sandy-hill, Glen's-falls and Fort-Ann, are at the junction of the Hudson valley from the west, and those of the South bay of Lake George and the Champlain valley from the north and northeast.
9. The sand plains of Greenwich and Easton about Galesville, are at the junction of the Batten kill with the Hudson valley.
10. The plains of Scaghticoke, are at the junction of the Hoosick and Tomhannock valleys with the Hudson valley.
11. The sand and gravel plains from Salem by Cambridge and Hoosick, are at the junctions of the valleys of the Batten kill, Wallamsack, Hoosick and smaller streams with the eastern channel of the Hudson and Champlain valley; and these are connected so as to unite in one deposit, or are but slightly interrupted.
12. The plains of Granville and Poultney, are at the junction of the valleys of Poultney and Pawlet rivers, with the eastern channel of the Champlain and Hudson valley.

The *smaller* sand and gravel deposits, as the Dover plains and Pine plains in Dutchess county; Somerstown plains in Somers, and Shrub-oak plains in Yorktown, in Westchester county; Copake flats and Ancram plains in Columbia county; the plains of White creek and Little White creek in Washington county; and many others of less note that might be mentioned, are in what seem to have been estuaries, or at or near the intersection of valleys, where eddy currents would necessarily have been produced by water flowing with a great depth.

Examples might be multiplied, but they all tend to show, 1st, that sedimentary depositions have taken place in times past, such as might be expected from the present drainage of the country, if the land was depressed from three hundred to one thousand feet below its present level.

2dly. The water currents from which these depositions have been made, have varied greatly in velocity at different periods at the same localities. The *clays* have been deposited in nearly tranquil waters, in horizontal strata, with thin interlaminated layers of sand, sometimes not thicker than the most delicate paper, while the laminæ of the clay are one-fiftieth to one-fourth of an inch in thickness. The *sand* beds have been deposited from water flowing with a gentle

current, with varying velocities, and in different directions; as is evident from the various sized grains in the different layers, and the lamination of the strata of sand and gravel. Good examples may be seen in the sand and gravel banks half a mile to one mile below Newburgh; in those at West-Point, Hudson, Marlborough, and at almost every sand and gravel bed in the Hudson valley (Vide Plate 27, fig. 1; Pl. 39, figs. 6, 7). Also examples of similar lamination in other formations (Pl. 4, fig. 12; Pl. 6, figs. 3, 4, 5, 6).

In regard to the deposits of Long island, I may perhaps be permitted to offer an hypothesis.*

1st. The gulf stream being due to general causes, as the rotation of the earth, the influence of the sun upon the equatorial regions, and the general form of the coasts of the American continent, may be supposed to have flowed in the same general direction in former times, (before the elevation in mass of the quaternary, tertiary and some other depositions above the ocean level, from the gulf of Mexico to that of the St. Lawrence,) as at present. The general contour and topography of our country at the quaternary period having been, in the main, the *same as at present*, as is evident by the level of the quaternary deposits, the gulf stream must have been propelled then, as it now is, along our coast, but nearer the mountain ranges. Such a stream would have a tendency to cause a transport of the alluvia brought to it by other currents, and deposit them in the eddies caused by obstacles or oblique currents meeting it.

2dly. New-England, and a small part of Eastern New-York, and probably portions of Lower Canada and New-Brunswick, are believed to have constituted a cluster of islands, the main north and south channel of which was that of the Champlain and Hudson valley. Through this valley, the current seems to have swept with considerable velocity, since the rocks in its bottom and lower parts are mostly bare, or only covered with coarse depositions, except where there were expansions of the valley, or such a contour of ground as to cause oblique currents, eddies and still water. In the Connecticut valley, the plains are regularly terraced, more like estuary deposits, showing the action of more regular and tranquil currents, as might be expected from the greater elevation of the valleys communicating with the St. Lawrence. The alluvia carried south into the ocean from these and smaller valleys, would be deposited on meeting the gulf stream, and drifted onwards to the east and northeast, as we see on the south side and central portions of Long island. Long island was evidently a bar, or bank of tertiary and drift, before the deposition of the quaternary strata.

If this explanation of the probable origin of the quaternary be true, that of Staten island may be referred to the same cause, perhaps, acting from the Hudson valley through the valley of the south branch of Murderer's creek, of Smith's clove, of the Ramapo and the Passaic as one current, with a branch along the southeast base of the Highlands from Stony point, and communicating with this current at the south line of Rockland county, where a creek

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* M. Dupont de Nemours, in his work entitled "Quelques Memoirs sur différens sujets," a work written about eighty-five years ago, says of Long island, that although not a delta in form, is one in reality, caused by the marine currents transporting the fluviatile alluvions of the Hudson, Passaic, Hackensack and Raritan rivers. He speaks of the granitic rock of Castle island, Staten island, New-York island, and for about three miles along the shore of Long island from Hurlgate towards Brookland.

joins the Ramapo; another through the valley of the Hackensack, from the Hudson valley near Haverstraw. This latter also undoubtedly communicated with the Stony point branch, leaving the Palisades as a cluster of islands in a curved line on the east and north, (as this range of trap rock is represented on the geological map of the State,) and the Highlands on the west as an island or a cluster of islands between that and the channel through Smith's clove. Another current may, perhaps, be considered as having passed through the Walkill valley, and communicated through the Pequanick river with the Passaic river, and as having contributed in the formation of the quaternary of Staten island. Another current may probably have flowed from the Walkill valley, through the Kittatinny valley, in which flow the Muskonekong, Pequest and Pawlings creeks, to the Delaware valley near Easton; and another through the Mamakating valley, from Kingston on the Hudson, to Carpenter's point on the Delaware; but these could not have contributed to the formation of Staten island.

The Shawangunk mountains and Blue mountains would thus form a long island. The Pochunk mountains, Mounts Adam and Eve, Lookout mountain, with the high ranges of hills to the northeast, terminating on the Hudson in Marlborough mountains and Huzzy hill, would thus have formed a chain of islands; Bellevale mountain, Sugar-loaf mountain, Sugar-loaf mate, Goose-pond mountain, Pedler's hill, Round hill, Brimstone hill, and Snake hill, another long group, including Skunnemunk mount, and the mountain region of the Highlands, between Bellevale mountain and Smith's clove.* The Highlands, including the Dunderberg, Colaberg and Haverstraw mountains in Rockland county; Bear mountain, Bare mount, Crow's Nest, Butter hill, Deer hill, Devil's peak, Black mountain and Pine hill in Orange, formed another island or cluster of islands. Breakneck, the Beacon mountains and Bull hill, would form one island or a small cluster, with a channel leading from Fishkill to Coldspring, and another to Peekskill, leaving Anthony's Nose, Sugar-loaf, and other mountains, between it and the Hudson river. Putnam county, in fact, would form a group of islands; and the continuation of this range of mountains north, through the south and southeast parts of Fishkill and Beekman, the west parts of Pawlings, Dover, Amenia, Northeast, and the east parts of Unionvale, Washington and Stanford to Winchell's mountain, which terminates in Northeast and Ancram, would form a long cluster of islands, with the main eastern channel extending from between Mount Washington and Winchell's mount in the valley of Oblong creek, through Northeast, Amenia, Dover, (where it would unite laterally with the Housatonic valley, but the continuation of the valley described passes south through Dover,) Pawlings, Patterson, Southeast, and down the valley of the Croton river to the Hudson valley.

Through all the straits or channels mentioned, viz. the Mamakating valley, Walkill valley, Smith's Clove valley, Haverstraw valley, Oblong and Croton valleys, and numerous smaller and lateral valleys, currents seem to have flowed to and from the Champlain and Hudson valley, and contributed their proportions in the formation of Long and Staten islands. The

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* *Smith's clove*, a place frequently referred to, is a deep valley crossing the Highlands, between and through the ridges, in a nearly north and south direction as a general course. The Ramapo flows from one end of the valley, and the south branch of Murderer's creek from the other.

transport of earthy materials seems to have been mostly in a southwardly direction. The perfect regularity of deposition of the clay in horizontal strata, thinly laminated with sand, and the thickness of this and the sand beds, show the lapse of a considerable period of time; but the extent, quality, and various phenomena of the depositions of clay and loam, are such as we might expect from water flowing with tidal currents, or with a steady current modified by the tidal flow, over a bottom and through valleys with the same forms they now present, but terminated by a more rapid current which has deposited the upper drift deposits.

It may perhaps be considered out of place in this report on the geology of *a part of New-York*, to speak of the geology of other portions of our country; but as the causes concerned in the production of many of the strata, and particularly those under consideration, were general over vast areas, I may be permitted to bring in for elucidation such facts as have been observed.

The geological reports of New-York, Ohio, Illinois, and Michigan, describe strata of *blue* and *buff marly clays* capped by sand or gravel beds. Both from the description, and from personal observation over most of the areas described, I am satisfied of the identity of age. The level at which these depositions now lie above the ocean, being so nearly horizontal, is remarkable, when we consider the vast area over which they are distributed.

Prof. Emmons has described the clay and sand beds that I have called *quaternary deposits*, along Lake Champlain and the St. Lawrence;* Prof. Vanuxem, similar ones through the great valley of the Mohawk and Black river, and in the continuation of the Mohawk valley to the west, and along the coast of Lake Ontario;† Prof. Hall, similar beds through the extension of the flat country from the Mohawk valley, by the north and south lakes to the Genesee valley, and on to Buffalo, and along the coasts of lakes Erie and Ontario;‡ and my own reports contain descriptions of similar deposits throughout the Champlain and Hudson valley.§ My own reports, and those of the assistants on the geological survey of Ohio, describe similar beds in that State; the reports of Dr. Houghton and his assistants, around the peninsula of Michigan; those of Dr. Owen, in the northern part of Indiana; and my own observations and the reports of others, have satisfied me that deposits of the same age occupy a large extent of country in Illinois, Wisconsin, Louisiana and Arkansas. Prof. Hall has also described some similar deposits, as terraces, in Upper Canada, like those in New-York, Pennsylvania, Ohio and Michigan; and the heights have been obtained by admeasurement with the level.

Col. Whittlesey has shown the levels of those in Ohio which skirt Lake Erie at a distance of one quarter to five miles, to be ninety to one hundred and twenty feet above the lake, or six hundred and fifty-four to six hundred and eighty-four feet above the ocean.‖ Towards the west end of Lake Erie, the terrace and ridge of an ancient beach recede from the lake far into the interior, showing bays up the valleys of all the principal streams, but parallel in its general trend to the Maumee river. In Michigan, a similar beach and terrace are described

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* New-York Geological Reports. † Ibid. ‡ Ibid.

§ Geological Report of New-York, 1837, p. 64; 1838, p. 158, 160; 1839, p. 70, 79; 1840, p. 226, 227; 1841, p. 71, 75.

‖ Geological Report of Ohio, 1838, p. 103; 1839, p. 55.

by Mr. Hubbard, sixty miles in length, at a distance of twenty to twenty-five miles from the lake, about parallel to the west end of the lake and the Maumee river, at a height of one hundred and seven to one hundred and eight feet above Lake Erie, or six hundred and seventy-one to six hundred and seventy-two feet above the ocean.* This is perfectly similar to that on which the Ridge road is located near Lake Ontario in New-York, and like that, is also used for a public highway. Those in Ohio are also used as public roads.

The following are some levels that have been ascertained by instrumental measurement (with the level), and may be useful in determining the sources of the immense volumes of water that have formerly flowed through the Mohawk valley, the Champlain and Hudson valley, and others that have been mentioned.

	Superior.	Michigan and Huron.	Erie.	Ontario.	Champlain.	Ocean level.
Height of lakes above the Ocean,	596*	578*	565*	232*	93**	
— of ancient beaches on terraces in Ohio, on lake coast,	....	....	90 to† 120	....	....	654 684
— of ancient terraces in Michigan, west end of Lake Erie,	....	....	107* 108*	....	....	671 672
— of terrace of lake ridge (ridge road),	....	....	....	160§	....	392
— of quaternary near Champlain,	....	....	....	....	150¶	243
— of ancient beach on terrace by Cleveland court-house, Ohio,	....	....	95‡	....	....	659
Summit west of Chicago, on route of the ship canal,	....	17	....	....	....	595
— of Maumee canal,	....	....	98‡	....	....	663
— between Lake Erie and Lockport,	....	....	25½	....	....	590½
— between Lake Michigan and Illinois river,	....	79†	....	....	....	657
— portage of Wisconsin, between Fox river of Green bay and Wisconsin river,	....	121*	....	....	....	699
— of Champlain canal between Whitehall and Sandy-hill,	....	....	....	....	147**	247
— between Lake Ontario and Mohawk valley,	....	....	....	....	....	400
Tertiary of Lake Champlain (quaternary),	....	....	....	....	200**	293
Gravel beds at West-Point,	....	....	....	....	....	188
Terraces on the Canadian side of Lake Ontario, measured by Mr. Roe, supposed by him to have been beaches at different times. (Localities not mentioned).‖ A	....	....	....	108	....	342
B	....	....	....	208	....	442
C	...	....	....	280	....	514
D	....	....	....	308	....	542
E	....	....	....	344	....	518
G	....	....	....	420	....	654
L	....	....	....	680	....	914
O	....	....	....	762	....	996

It follows from the above Table of Heights, that a depression of two hundred and fifty feet would cause the waters of the ocean to communicate through the Champlain and Hudson valley; one of four hundred feet, would cause the water of the Great lakes to flow through the Mohawk valley; one of six hundred feet, would cause the waters of the ocean, from the

* Geol. Report of Michigan, 1840, p. 104.
† Whittlesey. Geol. Report of Ohio, 1839, p. 55.
‡ Idem, 1838, pp. 103, 104.
§ Hall. Geol. Report of New-York, 1838, p. 310.
‖ Hall. Geol. Report of New-York, 1839, pp. 432, 433.
¶ Emmons. Geol. Rep. of New-York, 1837, pp. 107, 120.
** Idem, 1838, pp. 334, 335.

Gulf of Mexico, through the Mississippi and Illinois valleys, to unite with those of the St. Lawrence, Mohawk and Hudson valleys; one of seven hundred feet, would also, in addition to all these communications, open others between the Wabash valley and Lake Erie, and between Lake Michigan, through Fox river, across the Portage of Wisconsin, with the Mississippi valley. The summits here named are the lowest communications except the St. Lawrence river, between the St. Lawrence basin and New-York bay, and between the Great lakes and the Atlantic and Gulf of Mexico.

Most of the ridges that seem to have been beaches of the St. Lawrence valley, in Ohio, Pennsylvania, Michigan, and probably also in New-York, are at an altitude of between six hundred and seven hundred feet above the ocean; and most of the quaternary deposits I have been describing, lie at and below that level. These deposits show conclusively the existence of a vast inland sea, over a great extent of country that is now dry land; and the waters that filled this basin have, since the communication with the Mississippi valley ceased, flowed to the ocean through three main channels, viz. that of the St. Lawrence, that of the Champlain and Hudson valley, and that of the Mohawk valley, from Buffalo through the Tonawanda valley, and various points between Lake Ontario and the Mohawk valley.

As it is not probable that there is less water upon the surface of the earth at present, than at any previous time;* and as the ocean, by its fluidity, maintains its equilibrium, we have no alternative but to admit that a large portion of the American continent has been raised in mass, at the quaternary period, without any great alteration in the *relative* levels of the different parts, where minute examinations have been made, while the *absolute* elevation above its former level must have been from five hundred to a thousand feet. When the country shall have been more thoroughly explored, the *absolute elevation* can be determined, as the ancient beaches show where the water level *once* was, and these beaches are easily *recognized*, and have been formed since the drift deposits.

At the quaternary period, at the time of the formation of the terraces and "lake ridges" or ancient beaches, there can be no doubt that the waters of the Gulf of Mexico and of the St. Lawrence communicated through the Wabash and Maumee valleys; for the summit level of that canal is ninety-eight feet above Lake Erie, or six hundred and sixty-three feet above the ocean; and the ancient beach bounding this valley on the west is one hundred and seven to one hundred and eight feet above Lake Erie, or six hundred and seventy-one to six hundred and seventy-two feet above the ocean; so that allowing no alluvial causes to degrade the beach, or fill up the valley, there is a depth of eight or nine feet through which water may have flowed.

It is probable that a communication also existed between Lake Michigan and the Illinois river, but we lack data to give *certainty* to it; because the beaches, if they exist, have not been described, or their elevation given; and we are not certain that the *amount* of elevation

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* Water could have disappeared only by decomposition, and we know of no substance but water on the earth in any great quantity that contains hydrogen, so that the conclusion is *forced* upon us, that the quantity of water remains the same.

that that part of the country has experienced at that epoch, is the *same* as that around Lake Erie. If, however, we *suppose* it to be the *same*, it is probable that a *great volume of water* passed between Milwaukie and the south end of Lake Michigan, the lowest point of depression being near Chicago, and elevated only seventeen feet above the lake, or five hundred and ninety-five feet above the ocean, and would give a depth of water in the lowest point of seventy-six to seventy-seven feet, between the waters of the Gulf of Mexico and the St. Lawrence.

It has been shown that the gulf stream must, from the operation of general causes, have been forced upon our coast before this elevation of the quaternary; and *then*, as *now*, it must have elevated the waters of the Gulf of Mexico* above the ordinary ocean level. A portion of this would necessarily flow through the channels of communication between the valley of the Mississippi, which was once a gulf, and the basin of the St. Lawrence. This is the only way we can account for the *currents* that have flowed through the Mohawk, Champlain and Hudson valleys during the quaternary period; because, when so much of the St. Lawrence basin was covered by water, the water derived from rain, snow, and the drainage of the surrounding country, would not be *much* more than sufficient to compensate for its evaporation. So at that time, when the lakes were one sheet of water communicating with the Atlantic through many channels, the probability is that there would be but little current, except what would be due to tides, and these would be in opposite directions. During this period, the clay beds were probably deposited. If, however, the *gulf stream* caused a flow into Lakes Michigan and Erie from the Gulf of Mexico, it would account for the general *course of transport* of the deposits of the quaternary period in the Hudson and Mohawk valleys. The deposits of this formation are so similar through the whole of the St. Lawrence basin, and the Mohawk, Hudson and Champlain valleys, that they must all be referred to one general cause. The clays are marly; and throughout almost the whole southern border of this basin, the waters were in contact with calcareous rocks.

The upheaving action by which these depositions were elevated above the ocean level, caused the largest portion of the waters of this basin to drain off down to the present level, through the channels mentioned, namely, the St. Lawrence river, and through the Mohawk, Champlain and Hudson valleys. This would account for the greater acceleration of the currents, and the deposition of coarse materials, at the close of the quaternary period; for the outlets through the Highlands, the Walkill and Mamakating valleys, through the Champlain valley at the summit, and the Mohawk valley at the Little falls and the Noses, were limited in their capacity for drainage for so great a volume of water; and if the uplift was sudden, the rush of water through the narrow channels would necessarily be very violent, and from the quantity of water to be discharged, long continued. This would also account for

* The general contour of the coast was undoubtedly, in form, an approximation to what it now is, with the Cumberland mountains forming the southwestern cape, as the south end of Florida does at present, while the gulf extended far up the Mississippi and its tributaries.

the great accumulation of the sandy materials on the coast of Long and Staten islands; and the causes of the deposition of these materials there has already been given.

It has long been supposed that a great lake formerly existed above the Highlands, and many speculations have been made concerning it, and the rending of the mountains so as to drain it off; but the quaternary and drift deposits found in the valleys undisturbed, demonstrate that the channel through the Highlands existed nearly the same during those two epochs, as it is at present; so that from these circumstances we know it has been an open channel of communication between the Atlantic and the St. Lawrence basin, during, and since those two epochs.

The coarse deposits of gravel and pebbles, and even boulders, in the valleys near the narrow passes of the Highlands, of Little-Falls, the Noses, and wherever the current was confined, seems strongly to favor the view, that the elevation by which these formations were raised above the level of the sea, was *not so slow* an operation as that of the elevation of the coast of Sweden, and it may have been sudden.

I have seen but *two classes of facts* that afford evidence of a shifting of the position of rocks, that can be referred to *this* geological period, that might not have been produced previously.

1. One of these is a fault in the clay and gravel beds near Newburgh, where the clay and sand horizontally stratified were separated by a vertical line on the surface exposed, each abutting against the other, with little disturbance of either, and covered by beds of coarse gravel, evidently deposited after the fault had been formed. This locality was where there had been no slide or derangement of the strata since the deposit of the gravel beds, and where no present causes could wash the gravel, which was the top of the hill, and on a high bank where excavations had been made for clay and sand, about one-half or three-fourths of a mile below Newburgh on the shore of the Hudson. It was observed when making a geological exploration with a class of my pupils, from the U. S. Military Academy at West-Point, in 1834. Other facts of this class have been observed on Long island and in the Hudson valley, but less conclusive.

2. The other class is where the slate rocks on the east side of the Hudson valley had been ground down, smoothed, deeply grooved and scratched across their edges;* and since the action that had produced these effects, the masses of slate had been shifted a few inches in a vertical direction by a slight fault, so that the grooves and scratches on the *lower* part of the mass were continued quite up to that part that had been elevated; and on the *upper* mass, the same grooves that had been once continuous, were prolonged in their former direction, with the same breadth and depth. This shift of position, or slight fault, *must* have been *subsequent* to the period when the scratches were made, or the scratches could not have been continued close up to the vertical surface of the more elevated portion, and without wearing the sharp edge of the slate on the upper portion of the shifted mass. This locality was where the

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* Most of the rocks in place in the Hudson valley, when uncovered from the drift or quaternary that covers them in many places, show their surfaces to have been ground off, as if by the attrition of heavy moving masses of rock, and are scratched and grooved.

quaternary had covered it, but the example cannot with *certainty* be referred to that part of the quaternary period of which we are now speaking; for it *may* belong to the elevation that took place *after the drift period*, and *preceding* the elevation by which the quaternary deposits were raised to their present level.

The locality and example referred to above, was observed by myself in Copake or Ancram, near the north end of Winchell's mountain, and not far from the base of Mount Washington, on the road from Copake to Boston corners. Professors Merrick and Cassels* were present with me, and I called their attention to this, as an important fact for them to observe, in consequence of the *kind of evidence* thus afforded of the *relative periods of time during which the rocks were disturbed in position.* Prof. Merrick, a few days afterwards, in his explorations, discovered several more localities near each other, about half a mile west of Long pond in Clinton, where the same facts were observed. I quote his report to me.

"An interesting phenomenon may be seen in the rocks about one-half mile west of Long pond in Clinton. The parts of the rock have changed their relative position since they were worn down by the diluvial action. In two different places, at but a short distance from each other, one part of the rock has been raised, or the other part settled from two to three inches, the strata being nearly vertical. Five or six similar dislocations, of from half an inch to one inch, occur in the immediate vicinity.

"Of the dislocation of the rocks since the effects of the diluvial action upon it, there can be no doubt, as the scratches or furrows upon the elevated and depressed parts precisely correspond, and are carried on the latter entirely up to the former, the elevated ridge of which is unmarked or broken" (unbroken?). "These dislocations are exposed for twenty-five or thirty feet; and it should be remarked, that they do not occur in the vicinity of a ledge,† or upon the side of a hill, but upon a level surface upon the summit."

Recapitulation of the Results.

1. It is considered evident that a vast inland sea once occupied what may be called the Basin of the St. Lawrence and Hudson valleys, since the period of the drift deposits.

2. The materials deposited from the waters in that area during a considerable period of time, are such as we might expect in such a body of water, with a moderate flow through its channels of communication with the ocean, and having the general contour of its bottom and shores the same or nearly the same as we now find the topographical features of the country to be.

3. The water level has changed in this area; and as the ocean maintains its equilibrium, this vast tract of country has been elevated in mass with little *relative* change of height, but to an *absolute* height of three hundred to one thousand feet above its former level.

4. This elevation has probably been effected in a short time, and caused strong currents to

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* These gentlemen were assistants on the geological survey.

† *Ledge*, is here used in the sense in which it is often employed in New-England, to mean a *cliff* or *steep hill-side of rocks.*

flow through the channels communicating with the ocean, and through which the waters have been drained to their present levels, depositing beds of sand, gravel, pebbles and boulders in the eddies.

5. The fault at Newburgh shows derangement of the clay and sand beds *subsequent* to their deposition, and *preceding* the deposit of the pebble and gravel beds at that place; and probably this, and the dislocations of the slate, which were *subsequent to the drift deposits*, were effected at the period of the quaternary elevation.

III. DRIFT DIVISION.

This is intended to embrace the lower part of those deposits that have been called *diluvion, diluvium, terrains de transport, erratic block group, boulder system, terrains d'alluvion, terrains d'atterrissement, terrains diluviens, altere alluvial-bildungen*, etc.

The deposits and phenomena that I propose now to describe, might have been included in what have been described as quaternary deposits; but as the period of deposition of the mass of the drift deposits, as they are described in this volume, was *distinct* from that of the quaternary, and marked by strong features of distinction, it claims a separate discussion.

In describing the quaternary, a deposit of pebbles, gravel and boulders was mentioned as covering the beds of clay and sand in many places, which was called the *upper drift*. In consequence of these separate depositions of drift, and upper drift, being mistaken for each other,* but which are really distinct, (having been produced at different epochs, and under different circumstances,) the trains of causes and effects have been ascribed to one epoch. It is believed there is abundant evidence of two epochs, of strong currents, with a period of considerable duration of comparative repose between them, and that the waters at those epochs stood at different relative levels.

The causes that have produced the drift deposits have acted over all the northern and northwestern States and Territories, except limited areas, which will be mentioned in the proper place; and as so many facts have been now observed, as to offer some prospect of generalizing them, and perhaps arriving at correct conclusions in regard to the phenomena of the drift period, I may be permitted to draw facts that tend to elucidate the subject from the various sources of information to which I have access. It is a subject to which I have given much attention for many years, and my facilities for observation have been greater than falls to the lot of most persons, and the facts have been observed and studied over most of the territory belonging to the United States east of 97° of west longitude.

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* This mistake may easily be made in many places, even by the most experienced observers; for they are often blended by subsequent causes, and where the clay and sand beds are absent, cannot always be distinguished.

My duties as an officer in the Army caused me to travel over some parts of the United States that I should not otherwise have seen. For several years, all the time that I could be spared from my duties as an instructor of mineralogy and geology at the United States Military Academy at West-Point, was spent in travelling to acquire a knowledge of the geology of the country, when I could raise funds enough for the purpose ; and since then, the various geological surveys on which I have been engaged for the Government, for different States, for mining and other companies, and for individuals, have brought under view the geological features of the largest portion of our country. These various causes have led me to travel in the States and Territories more than one hundred thousand miles, in examining its mineralogy and geology.

Position of the Drift Deposits, geological.

The drift deposits of the Hudson valley, and of the First Geological District generally, except Long and Staten islands, are found lying upon the naked rocks of all the formations that are consolidated. On Long and Staten islands, this formation is observed in many places resting on the subjacent sand and clay beds, of a formation that is supposed to belong to the tertiary period. Over most of New-York, New-England, Ohio, and of the States and Territories northwest of Ohio, the drift deposits, so far as investigation has gone, are superposed on the rocks in place, which generally show smoothed and scratched surfaces, as if worn off by attrition, and the moving of rocky masses along their surfaces ; and this is more particularly the case on elevated grounds, than in the bottoms of deep valleys.

The drift deposits of the period I am now describing, are often covered to a greater or less depth in the large valleys by depositions of clay, gravel and sand. These quaternary deposits are common in the valleys up to a certain level, at which it has been shown that the water remained for a considerable period, when it formed the beaches and terraces around the lakes, and deposited the quaternary strata. The drift depositions occupy situations much higher in absolute level than the quaternary, and in the valleys also are found at lower levels, underlying them. The drift deposits were undoubtedly transported by water, and this would show that the waters occupied a higher level, or that the present surface of the portion of our continent now under consideration was relatively less elevated at the drift. than at the quaternary period. The following localities may be referred to, as a few of the numerous examples observed, where the order of superposition is manifest.

1. One or two miles south of Negro point in Putnam, on Lake Champlain. The limestone rock is scratched and overlaid by a deposit of boulders, pebbles, gravel and clay ; and this deposit is overlaid by the clay beds of the quaternary.
2. Numerous examples may be seen around Newburgh bay, on the west shore, between Butter hill and Newburgh, where the drift bed, containing boulders and pebbles that are scratched, overlies the abraded and scratched slate rocks, and is itself overlaid by the clay beds of the quaternary.

Where excavations, or the wash of the waves expose the slate and overlying drift deposit, these abraded pebbles and boulders may occasionally be dug out.*

3. Montauk point is a good example, and all the south shore for some distance west; the drift deposit is well exposed in high banks, and is covered in some places by the quaternary sands, clays and loams. (Vide Pl. 4, fig. 2.)†

Composition of the Drift Deposits.

The drift deposits are composed of fragments of all the preëxisting rocks, exposed to the action of the causes that have contributed to their transportation and deposition. They are mostly coarse, composed of blocks, boulders, pebbles, gravel and sand, sometimes loose, but frequently partially aggregated by argillaceous matter, that renders a pick necessary to dig it. Most of the material that is called "hardpan"‡ in New-England and New-York, and "marl" on some parts of Long island, is formed of blocks, boulders, pebbles, gravel, sand and clay, partially cemented by the latter. The gravel beds are also cemented by carbonate of lime into a coarse sandstone and conglomerate, by the action of alluvial causes. This may be observed at West-Point, and between Washington's valley and the base of the Crow's Nest, on the west shore of the Hudson.§

Topographical Features.

The topographical features of this formation are somewhat peculiar. In the eastern and southern parts of New-York, and in Massachusetts, Rhode-Island and Connecticut, the drift, where it is well exposed to view, is very hilly and irregular, and is composed of round-backed hillocks with bowl-shaped cavities or valleys between them. These little hills are entirely

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* Vide Plate 27, fig. 4.
T, Sand and gravel beds.
T', Grey clay.
T'', Blue clay.
T''', Drift of boulders, pebbles, gravel and clay.
H, Slate rocks of Hudson slate group.

† This figure is corrected as it should be under the quaternary deposits in this volume, page 126.

‡ The term "hardpan" is also applied to what Prof. Eaton has called *analluvium*, or *rock crumbled and disintegrated in place.* They are easily distinguished.

§ Geological Report of New-York, 1838. Final Report, 1842, p. 123. Mather on Diluvion; printed for the Cadets of the United States Military Academy, 1835, p. 7.

Prof. Hitchcock has also described consolidated gravel, three miles from Williams College in Pownal, Vt. I have also seen the locality. A deposit of similar characters occurs at Zanesville, Ohio; also at the Narrows in the valley of the Scioto, two miles from Chillicothe. Dr. Houghton and others describe it also in Michigan. It is not uncommon in the United States, but the above are the principal localities that have been described, and all of which, except those in Michigan, I have examined.

Dr. Buckland has mentioned consolidated gravel in Europe, near the Monastery of Kremminster in Upper Austria, where it is quarried for building, and contains the bones of the Ursus spelæus (Rel. Diluvianæ, p. 101); also in gravel pits near Oxford, England (Reliquæ Diluvianæ, pp. 71, 160). Prof. Briggs describes consolidated gravel, and pudding-stone cemented by carbonate of lime, in the gravel beds near Troy, N. Y. (Field Notes of Geol. Survey, 1st Dist. Vol. 2, p. 8.)

composed of boulders, rounded pebbles, gravel and sand.* They may be seen in the valley that extends south from Fishkill by Haight's tavern, through the Highlands in Putnam county, to Coldspring and to Peekskill ;† and in most of the elevated valleys through which currents seem to have flowed, when the water was elevated some hundred feet above its present level.‡ On the island of New-York, these hills were very common in the present upper part of the city a few years ago, but most of them have been cut down in grading for streets.§ On Long island, these hills form an elevated ridge, called by some the "Green mountains," and by others the "Backbone" of the island, and extend from New-Utrecht by Brooklyn, Williamsburgh, Jamaica, Oysterbay and Smithtown, to Oysterpond point; and once extended perhaps to Plum island, Gull islands and Fisher's islands.‖ A branch of this ridge of drift hills extends from Smithtown through the south branch of Long island to Montauk point, and probably once extended to Block island.¶ Both these ranges of hills are interrupted in many places, where channels seem to have been subsequently made across them. Staten island shows hills of the drift on its eastern part, at Forts Tompkins and Richmond. Many of the small islands in the narrows of Long island sound, and between there and New-York, show the same general characters. In many places, the islands that have drift deposits are covered more or less with some of the strata of the quaternary. The hilly region of Long island shows the characters of the drift deposits better perhaps than any other portion of our country, except the southeastern part of Massachusetts, where the hills are sometimes one hundred or two hundred feet high.** Some of these hills on Long island present elevations and depressions of one hundred feet or more, and the highest point of these hills is four hundred and four feet above the ocean. The country around Montauk point, on what is called Shawango neck (once an island), shows this hilly character of the drift to as great advantage as perhaps any other on Long island. The hills have a nearly uniform character, round-backed, with deep valleys without any approximation to regularity, unless their tendency to a bowl-shape be so construed. The valleys have no outlets, and the water that falls or drains into them, either sinks into the soil, or collects sc as to form "pond-holes." The hills are in form like potato hills, but disposed helter-skelter, and are from twenty to eighty or one hundred feet high. At the Shinnecock hills, west of Southampton, near Canoe place, and Dix hills, four

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* Mather's Geological Survey of New-London and Windham counties in Connecticut (Norwich, 1834, p. 34.) Hitchcock's Geological Report of Massachusetts, 1833, p. 144; 1835, p. 150; 1841, p. 366.

† Mather on Diluvion; printed for the Cadets of the United States Military Academy, 1835, p. 7.

‡ The same kind of diluvial hillocks, as they are sometimes called, are in the valley of Wappinger's creek, between Fishkill and Poughkeepsie; in the Mamakating valley, between Wawarsing and Wurtsboro'; between Johnstown and Hudson; the plains north of Valatie, Columbia county; in Greenbush and Nassau; on the road between Lansingburgh and Schaghticoke, in Rensselaer county; in the valley between Ameniaville and the Furnace four miles south; along the eastern part of Fishkill near the base of the mountains, near Shenadore and Stormville in Dutchess county, New-York.

§ Gale. Geological Report of New-York, 1839, p. 178.

‖ Dr. Mitchill. Mineralogical and Agricultural Report, 1802. (Medical Repository, 1802, p. 214.)

¶ Vide Alluvion, marine alluvial detritus, in this volume, p. 30; New-York Geological Report, 1838, p. 133; Mitchill in the Medical Repository, 1802, p. 213.

** Hitchcock. Geological Report of Massachusetts, 1841, p. 367.

miles west of Commac, the same characters of the drift hills are observed, but on a smaller scale.

It is only where the drift deposits have a considerable thickness, that the hilly character of the drift is observed. Where it is thin, it does not give any marked character to the country, but serves to fill up the irregularities that would otherwise exist upon the rocky surface, and give a smoother outline. A large portion of the surface of the earth in the First district of New-York, and in New-England, Ohio, and all the western and northwestern States and Territories, is covered by a mantle of the drift deposits. The drift is frequently covered, in the valleys and depressions of the surface, by the quaternary and alluvial deposits; but it may perhaps be safely said, that three-fourths of the surface shows this deposit, often very thin, but frequently of considerable thickness.

In the prairie regions of the western and northwestern States and Territories, this formation has a great development, covering almost the whole face of the country, and showing strongly marked topographical features. Where the drift alone forms the surface, and has some considerable depth, it forms undulating plains, dotted with numerous boulders and blocks upon its surface, and in some localities showing the same characters of hills and valleys, as have been described on Long island and other localities. This is the case in some parts of the plains at the base of the Coteau de Prairie.*

These vast plains, composed of drift, covered in some places by alluvial and quaternary deposits, are boundless to the eye, and the traveller passes across them guided only by his compass, like the mariner upon the ocean, and the same mirage is there observed. When a distant island of woodland first makes its appearance in the horizon, showing the tops only of the trees, a person unacquainted with such deceptions would be apt to think he saw a broad lake intervening, and perhaps describe such in his travels. Objects are strangely magnified, and a small swell at a few hundred yards distance, with some weeds upon its summit, might easily be mistaken for a high range of land covered with trees.† These appearances were more marked and distinct where the prairies had been recently burnt over, and the blackened surface, heated by the sun's rays, caused more than ordinary refraction in the atmosphere. The light and shade visible on an unblackened surface, and almost all objects that might have been used as sources of comparison, were wanting.

The terraces that bound these vast plains of one level, are but the edge of others as vast, and in the horizon have the aspect of a distant coast; and this appearance has given the name to the Coteau de Prairie. These terraces in some places present another appearance like a coast line, as perhaps they were in some former time, probably at the quaternary period. Boulders in immense numbers are seen on the faces of some of these terraces, *lying in a*

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* Vide Featherstonhaugh's Geological Report, 1836, p. 153. "Sand hills" should have been described as hills of gravel, pebbles, boulders and blocks. M. Vide also Mather's Geological Reports to the Secretary of War, MSS.

† Such facts, and numerous others, were observed by Mr. Featherstonhaugh and myself in a geological reconnoisance to the Coteau de Prairie in 1835, and are described in our reports to the Secretary of War. Vide Mr. Featherstonhaugh's Geological Report, 1836, pp. 153, 156; and Mather's MSS. Geological Report to the Secretary of War.

horizontal plane nearly, *as far as the eye can reach*, like a shore where the banks above had been washed away by the waves, and left the boulders and blocks that had been imbedded on the shore. A prominent example of this kind may be seen on and from the trail, from Fort Renville at the foot of Lac qui Parle, to Lac Travers, on the terrace of the High prairie. Where the prairie itself is on the same level as the line of boulders, it is so thickly strewed with boulders and erratic blocks, that a person may walk on them for considerable distances without stepping on the ground. Boulders are now being deposited in a manner perfectly similar in appearance to these belts and flat areas, around the shores of that lake, by means of ice. The ice encloses the boulders and blocks in shoal water, and in the spring, the swell of the lake, by the melting snows and the rains, float off the masses, and the wind drives the ice on the shores and on the marshes around the lake, where it melts, and deposits its freight of rocks, gravel and pebbles. This is a prominent feature on almost all the lakes far to the north, where they are surrounded by drift deposits, or where loose rocks had been by any means left in shoal water. They are piled up along the shore in great numbers.*

Boulders and blocks are very common in many parts of the country, collected in groups, where, in a small area, are hundreds or thousands, and sometimes hundreds of thousands of tons of them; while all around, few or none are observed. Col. Abert, Chief of the Topographical Bureau at Washington, first called my attention to localities of these trains of erratic blocks in the United States in 1835. He had seen them thus grouped on the prairies in the central parts of Illinois, and I have since seen similar facts on the northern prairies in Iowa;† on the Coteau de Prairie;‡ on the terraces two hundred or three hundred feet above Lake Erie, in Ohio; on Long island, and in some of the valleys of the Highlands. They have been long known in Europe. They often form a striking feature of the country.

Boulders and Erratic Blocks.

The term *boulder* is applied to rounded masses of rocks, that are supposed to have been worn to their rounded forms by attrition. The term is, by common usage, applied to masses from six inches diameter, to the largest sizes; but many of the large rounded masses called boulders, have received their forms by the *atmospheric causes* producing *disintegration*, by which the edges of angular blocks crumble more rapidly than the other portions. I have seen this effect produced so frequently, that there is not the slightest doubt, that many of the rounded masses described as *boulders*, owe their forms to this cause.§ It is not doubted,

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* These facts in relation to an ancient coast line, but subsequent to the period of the drift deposits, should have been mentioned under the quaternary deposits; but there are many more facts somewhat analogous to these, that properly belong to the drift for discussion.

† Featherstonhaugh's Geological Report, 1836, p. 141; Mather's MSS. Geological Report to the Secretary of War, 1836.

‡ Mather's MSS. Geological Report to the Secretary of War, 1836.

§ This change may be seen well illustrated in Foster (R. I.), on the road from Sterling (Conn.) to Providence (R. I.), in a range of trappean rock a few rods east of the principal branch of the Moosup river. (Vide Mather on Diluvial Deposits, 1835,

however, that the banks of rounded masses of rock, pebbles and gravel, indicate the action and transporting power of water. An examination of the manner in which pebbles are formed in a rapid stream, or on a shingle beach; the manner in which sand, gravel and pebbles, are deposited where washed along by water, till they find a resting place, and then comparing the appearances with those of the beds alluded to, will convince the most skeptical.

The terms *boulders* and *erratic blocks*, also imply that these masses of rock are more or less removed from the place where they were formed. They are loose masses, spread over or imbedded in the soil, and frequently they are different from the rocks in place in the vicinity; but it is observed as a *general* rule, that the larger masses and blocks are nearer their parent sources, while they diminish in size as they are more remote from them. These boulders and blocks are scattered not only over the valleys, plains and hills of moderate elevation, but they are found on the peaks of high mountains. The boulders, blocks, pebbles, gravel, etc. of the drift, embrace specimens of all the various rocks in the district where they are found, that are able to withstand the rough usage to which they seem to have been subjected.

The materials of the drift deposits, from the gravel, to blocks and boulders weighing hundreds of tons, are often far distant, not only from hills and mountains, and from every known locality from which they may have been derived, but are separated from their parent sources by immense plains, broad and deep valleys, or by broad and deep lakes and arms of the sea.

Notwithstanding all the study and investigation that have been bestowed upon the subject of the drift deposits, or diluvion, no one solution will account for all the phenomena of this interesting geological problem.

It has been stated in my annual Reports on the New-York Geological Survey, that the sources of the boulders and drift of Long island and the Hudson valley, were in a northwardly direction from the locations where they are now found. The facts will now be stated in regard to the boulders and drift, and for the upper drift as well as the lower, since the materials of both are the same, and in many localities on Long island they cannot be distinguished. These facts are the basis from which conclusions were drawn in regard to the direction of transportation in the First Geological District. The reader can examine them, and judge if the conclusions are well founded.

The observations on boulders and drift on Long island will be first stated; then those of other islands, as Staten, New-York, Fisher's, &c.; then those of the counties up the Hudson and Champlain valley; and then those of the Delaware and Susquehannah, of the country around the Great lakes, of New-England, and of the Middle and Southern States.

The facts stated are mostly the results of observations on the geological survey of New-

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p. 24.) Also in a range of gneiss that rapidly disintegrates, extending from Stonington through Voluntown in Connecticut, and Coventry and Foster in Rhode-Island. (Vide Mather's Geol. Survey of New-London and Windham counties in Connecticut, 1834, p. 8.) This character may also be seen well illustrated in North Carolina, and in many parts of the gold region of the Southern States, where the less easily crumbling masses of granite and gneiss lie upon the surface of the earth or of the rock, and have been mistaken for boulders.

York, but the cause that has effected the transportation of the drift deposits has acted over most of the northern parts of the United States; and I have felt myself authorized, in discussing it, to bring forward such observations as have been made, and which may enable some one to reconcile all the apparent contradictions, and eventually to unveil the secondary causes* that have produced the results we see.

Boulders and Drift of Long island.

Blocks of granitic rock were seen in a small hill on the road from Sag-Harbor to Easthampton. *Near Easthampton,* on the shore, the surf frequently uncovers the drift that underlies the superior sands and clays. This formation of gravel, pebbles and boulders, is more or less cemented by clay. It is of unknown thickness in that vicinity, and contains *quartz* pebbles of a yellow color, intermixed with those of *granite, sienite, greenstone* and *hornblende* rock. I have seen the same bed in a great number of places in that vicinity, and it must be very undulating in form upon its proper surface, as it frequently emerges on level ground from the beds of sand, loam and clay that overlie it. This is also the water-bearing stratum; and the wells are sunk to this stratum, or to such a level that the inequalities of its surface dam up and hold the water.

A block of *granite* was observed on the road from *Easthampton* to *Montauk point,* just before descending the sand hills and plains to Nepeague beach. After crossing Nepeague beach and marsh, which are entirely alluvial, and over which the sea still makes a clear breach during heavy storms, the hills of drift commence, and extend with some interruptions to Montauk point. The drift is in many places overlaid by sandy and gravelly materials, and in some places by clay. From Nepeague beach to Fort pond, the soil is sufficiently porous to absorb the water that falls upon it, without forming marshes or "pond-holes" in the depressions between the hills; but from Fort pond to Great pond, it is sufficiently clayey to be impermeable to a considerable extent, and cause marshes and small ponds. Between Great pond and Montauk point, the ground is less marshy, but there are numerous pond-holes in the bowl-shaped depressions between the hills. The drift formation is well exposed to minute observation along the south shore of Long island, for nearly ten miles west from Montauk point, and along a part of the north shore also to Great pond. Most parts of the coast between the points indicated are gradually washing away, as has been explained under *Alluvion* (*encroachments of the sea*) in this volume. The cliffs are of the formation under consideration, and are composed of clay or loam, through which gravel, pebbles and boulders, from a grain to many tons weight, are diffused. The surf beats against the base in high storms, washes away the clay and other materials, and the cliff not being sufficiently supported at the base, cracks off and tumbles or slides down. The loose earth is washed away,

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* God is the primary cause of all, who does all things by his might and power and wisdom, who governs and directs all things for the greatest good of the subjects of his power, and for his honor and glory. Man is permitted to unveil some of the laws of nature, as they are called, and trace out secondary and more remote causes.

the boulders and pebbles form a beach, and for a time protect the cliff; but these are gradually ground up by the action of the surf, or swept away. These cliffs are from twenty to one hundred and forty feet high.

The *boulders* and *pebbles* of these cliffs consist principally of *granite* of a rather fine grain, with a base of red feldspar and smoky quartz. The mica is small in quantity, and in many blocks is absent. *Coarse granite*, *gneiss*, *hornblende rock*, *greenstone*, some *mica slate*, *talcose slate*, *chlorite slate*, *hornblende slate*, and *red sandstone*, were observed.

The red granite is similar in aspect to that extending from Stonington north-northeast through Voluntown (Con.) and Foster in Rhode-Island, and is properly a thick-bedded gneiss; but in ordinary sized boulders, would be considered and described as granite. The coarse granite can be referred to granite veins of similar characters in Rhode-Island; the gneiss also to Rhode-Island. The hornblende rocks (some of the masses at least) are *peculiar*, and I have seen such in place only in the east part of New-London and Windham counties in Connecticut, and the west part of Rhode-Island. When wet, it is quite green, almost like the carbonate of copper. The hornblende slate is like the range of that rock, extending from Groton in Connecticut, through Preston, Plainfield, Brooklyn and Thompson into Massachusetts, and contains chlorite and epidote as common minerals.* It is peculiar in its aspect, and the layers much contorted. The greenstone is compact trap, like the dykes that traverse the gneiss rocks in Windham, Lebanon, Marlborough, &c. in Connecticut, and those of the region around Smithfield and southwest of Newport in Rhode-Island. The mica slate was like the range of mica slate extending from Bozrah in Connecticut, through Hampton, Pomfret and Woodstock, into Massachusetts. The talcose and chloritic slates were like the metamorphic slates, that may be classed under those names, on the island of Rhode-Island. A single pebble of a rock that has been found in place in Naragansett bay, only, was found. It is an altered metamorphic rock, that has been called *greywacke*, and *talcose slate*, but is peculiar in its aspect, and contains flat, black, tabular crystals. The red sandstone, when first seen, was supposed to have been left there accidentally, transported by human agency; but afterwards I saw it in numerous places on the hills, on the beaches, and in the cliffs over most of this part of the island, called Shawango neck. It is perfectly like the red sandstone of Chatham in Connecticut, where it is extensively quarried. Nearly all the rocks mentioned, even the large masses imbedded in the cliffs, had their edges and angles more or less rounded off, and very many of the smaller masses were rounded pebbles.† The minerals observed in

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* This range of rock is described as "contorted gneiss and hornblende slate," in my Sketch of the Geology and Mineralogy of New-London and Windham counties in Connecticut. (Norwich, 1834, p. 12.)

† On the neck between Great pond and Fort Pond bay, which was once an island, great numbers of boulders were seen. They were generally similar to those of Shawango neck. A reef of rocks (boulders and blocks, it is believed,) extends out some distance from the shore, on the northern extremity of this neck at Culloden's point, an indication of the wasting away of the land. The same fact may be observed on Shawango neck at Jones reef, about a mile west of Montauk point, and at Shagwam reef, about three miles west of the same place. This latter reef extends out north about three miles from the shore, and is supposed to be composed of blocks and boulders that have remained after the washing

this tract (Shawango neck) were quartz (transparent, milky and smoky), feldspar (white, red and yellow), mica (black, white and silvery), hornblende (green, black, fibrous, lamellar), chlorite, talc, titaniferous iron ore in granite like that of Foster (R. I.), garnet crystals in granite and mica slate, staurotide in mica slate, and oxide of manganese in pebbles of a few pounds weight. Magnetic iron sand and garnet sand were found on the beaches. The iron and garnet sands are very beautiful.

Boulders were frequently seen *in the hills west of Three-mile harbor*, in Easthampton, of from forty to sixty tons weight, and smaller ones were numerous. In digging wells in Easthampton, thin layers of clay are sometimes found in the sand and gravel beds; sand and light or heavy loam are passed through, and boulders sometimes found imbedded; and when they reach a bed of pebbles and gravel, water is obtained, generally within fifteen feet of the surface.

Between *Springs* and *Fireplace*, in the northern neck of Easthampton, the surface is strewed in some places with boulders and blocks of *granite*, *gneiss* and *quartz rock*.

In *Southampton*, boulders occur in abundance on the hills south and southwest of Sag-Harbor, and on Hog neck. In the range of hills between Sag-Harbor and Canoe place,* the boulders were numerous, composed of *granite*, *gneiss*, *mica slate*, *talcose slate*, *quartz*, *greenstone trap* and *hornblende rocks*. These hills are called the *backbone of the island;* and near Canoe place on the east, they are called the *Shinnecock hills*. They are composed of sand and gravel; and on the hills are seen boulders and blocks of *granite*, *gneiss* and *greenstone*, from one hundred pounds to one hundred tons weight each, but the very large ones are rare. These rocks are dug and blasted to make cellar walls and underpinning for buildings, at Southampton. The relative abundance of these rocks is in the order mentioned. The greenstone trap became more and more abundant in boulders and pebbles from Southampton to Canoe place. Most of the pebbles of the gravel beds are of white quartz, intermixed more or less with those of granite, gneiss, mica slate, red sandstone and red oxide of iron. This latter mineral is found in all the gravel banks of the quaternary formation, from Montauk point to Brooklyn. In some places it is so abundant that it might be an object to collect that on the surface as an iron ore, but not to make it an object of exploration by excavations. It is composed of red oxide of iron in brilliant grains, like iron sand firmly aggregated, but of a red

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away of the land in which they were contained. The drift deposit on this part of Shawango neck is low, and not more generally than fifteen to forty feet above the sea.

On the west side of Fort pond and Fort Pond bay, great numbers of boulders and blocks were seen scattered over the hills. They were generally similar to those of Shawango neck. Great numbers of them, particularly the largest ones, had excavations made on the east side of them. I learned afterwards that these excavations had been made, like those at Kidd's Rock point, and other places on Long island and along the Hudson river, by credulous persons hunting for the money reported to have been buried by the noted Pirate Capt. Kidd, who is said to have killed the sailors he had employed to bury the money, as soon as the work was done. Singular ceremonies were performed by these persons, to keep the devil away during their search!!!

* Canoe place is a very narrow isthmus of elevated land between Shinnecock bay and Great Peconic bay, across which the Indians formerly dragged their canoes between the waters of the Ocean and of Long Island sound.

color, and gives a bright red streak when scratched. It is called by the inhabitants *red chalk*, in consequence of its being used for a similar purpose. It frequently embraces the remains or impressions of plants.* It seems to have been iron sand on the *ancient* beaches, like that so often seen on the beach at the present time, but since aggregated into solid masses, enclosing organic substances, and changed to a peroxide of iron. Some of the specimens, however, have a striking resemblance to the clay ironstone of the coal formation, only changed to a peroxide of iron. The boulders in the Shinnecock hills are not confined to the elevated lands, as they are in most parts of the island, but are found at low levels as well as high. On the north side of Shawango neck, and at Oyster ponds, and thence to Rocco point, and near Horton's point, they are also at a low level; but generally, the drift bed is elevated above the sea level, and the boulders on the beach and at a low level are the result of the degradation of the land by the sea, and the crumbling down of the cliffs.

In the Shinnecock hills, the boulders in some places seem to lie in groups; but this character is not strongly marked there, as it is in many parts of the country. On the road two miles south of Sag-Harbor, the blocks and boulders are so numerous, and in such clusters, as to almost induce one to suppose the rock in place just below the surface. Most of these rocks bear a strong resemblance to the gneiss of Haddam in Connecticut.

In Southold, the surface is generally a loamy gravel, or light loam. Boulders abound about Horton's point, and thence to Rocco point; also northeast of Oyster Ponds harbor, on the hills. A section of the boulder stratum is represented on Pl. 27, fig. 3, about one or one and a half miles east of Horton's point. A topographical sketch is also given of the place where the section was made across the beach. Boulders are numerous on the points at the extremities of the beach, and along the shore east and west. The layers of clay were much contorted in many places, but the section gives the order of superposition. The clay contains in some places large masses of sand (several gallons), which, from their form, seem to have resulted from the disintegration of boulders while imbedded in the clay. The upper clay bed contains many pebbles, like that used in brick-making at Sag-Harbor, and many other places on the eastern part of the island. The boulders on the hills and shore consisted mostly of red granite and gneiss, like those of Stonington, Lyme, New-London and Waterford in Connecticut. Hornblende slate, green sienitic hornblende rock and greenstone, like those of Stonington and Groton, were observed.

Plate 4, figs 1, 3, 7, 9, shows the position of the drift. Fig. 3 is a section at a rocky point about half a mile west of Brown's point. The strata of sand and clay beneath are undisturbed; and we can scarcely credit that such enormous boulders and blocks, as may be seen in the boulder stratum, should have been transported by water currents alone, without washing away these deposits of sand.† No blocks or boulders are seen except in that stratum,

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* Specimens may be seen in the collection in the State Museum, among the specimens of drift from Long island.

† Two or three days before my visit to this part of the coast of Long island, there had been a tremendous northeast storm, that caused a great destruction of property, and made great inroads upon the coast, exposing beautiful coast sections, fresh, and that showed the order of superposition of the various strata perfectly.

unless where the inroads of the sea have washed the cliffs, and caused them to tumble or slide down to a lower level. The beach along most of the north shore of Long island is strewed with boulders from this cause. A little farther west, about one mile and a half west of Brown's point, the effects of land-slides may be plainly seen. The waves undermine the cliffs, the land-springs make the subjacent clay slippery, and the masses crack off at the top of the cliff and slide down; and the lighter materials being washed away, the boulders and blocks are left on the shore. This is illustrated in fig. 9, Plate 4.

Many curious blocks of granite, gneiss and hornblende rock, occur on the north shore of Southold, showing quartz, granite, trap, etc. veins cutting through them. Plate 36, figs. 1, 2, 3, 4, illustrate some of these. Fig. 1 is a sketch of a block of contorted hornblendic gneiss, with granite veins. It lies, or did lie, on the shore about north of Latham's Hotel, half a mile west of Oysterpond point. Fig. 2, represents a block of contorted hornblende slate, containing contorted branching veins of reddish granite of a moderately coarse grain, and a large vein of fine-grained reddish grey granite a foot wide. This block was observed on the north shore, on a point opposite to Greenport, and west of a lane leading to the shore from that village. Fig. 3 is a sketch of granitic gneiss, not fissile, and very slightly striped by the arrangement of its materials, containing a *contorted vein of fissile hornblende slate!* This block was in the water north-northwest of Oysterpond Point Hotel, about three-fourths of a mile west of Oysterpond point.

On the beach at Oysterpond point, white siliceous sand, red garnet sand, black iron sand, pebbles of greasy quartz, feldspar, porphyry, greenstone, granite, gneiss, mica slate and quartz rock (granular), are found. Boulders of granite and gneiss, and some few of other rocks, are found at the point, and on the north shore west of it. This point of land is washing away continually, and this subject is spoken of under Alluvion; but as Dr. Mitchill's observations on this locality in the year 1800 have come to my notice since that article was printed, the following extract from his observations is here introduced: "There can be no reasonable doubt that this detached piece of land (Plumb island) was formerly connected with Long island at Oysterpond point, from which it is now distant about three quarters of a mile in a northeasterly direction. The Indian tradition is, that the distance was formerly very small."* The distance is now probably more than a mile, perhaps a mile and a half. The shore of Plumb island opposite is also washing away.

Some of the erratic blocks of Long island are of great size. One on Mr. Latham's farm at Oysterpond point was mostly blasted to pieces, and made into a stone fence. He stated that the fragments made eighty rods (one-fourth of a mile) of stone fence, four feet high. A portion still remains in the ground. The portion used must have weighed more than nine hundred tons.

At Horton's point in Southold, the boulders and blocks of granite and gneiss cover the beach under the cliff. They fall from the upper stratum, like the boulder stratum of Brown's

* Medical Repository, New-York, 1802, Vol. 5, p. 214.

point and other places. Some of the blocks weigh from one hundred to five hundred tons. Boulders, blocks and large pebbles of red sandstone, like those of New-Haven and Cheshire in Connecticut, occur here in some abundance. A few blocks only of conglomerate, of the red sandstone formation, were seen.

On the north shore opposite Greenport in Southold, the cliff had been washed away at its base, at the time of my visit, so as to expose its stratification. The base of the cliff consists of sand, gravel and pebbles, horizontally stratified. These materials are variously colored, and are overlaid by the greenish and bluish loamy stratum containing the blocks and boulders.

In Riverhead township, from Roanoke point for two or three miles east, the shore is skirted by a high cliff composed principally of clay and sand, the clay forming a layer above the boulder stratum, as well as in the strata below. The land-slides of this part of the coast have already been described.* Boulders are seen in the greatest profusion along the shore. The boulders and pebbles lie at a depth of twenty or thirty feet below the surface of the earth at this place, and for a mile east. The boulders, blocks and pebbles seem to be collected in groups or nests in particular localities here, as at and near Brown's point, and Horton's point, etc.

At Roanoke point, and for three or four miles east, a large proportion of the blocks, boulders and pebbles are of red sandstone and trap rocks, like those of New-Haven and that vicinity. In some places these rocks form one-third of the mass of boulders, blocks and pebbles. The sandstone is of the coarse, fine and fissile varieties, and often quite micaceous. The trap is greenish, compact, vesicular and amygdaloidal.

At Hudson's point, three beds of clay are visible in the cliff; the upper greyish, the middle bluish and containing pebbles and some boulders, the lower brownish with a tinge of red, like that in the same geological position at Brown's point, Oysterpond point, etc., and belonging to the tertiary. These three strata at Hudson's point display a thickness of from sixty to one hundred feet.†

In Brookhaven township,‡ a block of gneiss was seen a few rods from the road, on the north side, about a mile east of Coram. It is possible that it may be rock in place, as it lies on the ridge, is stratified, and its line of bearing is about N.N.E. and dip 60° to 80° W.S.W., conforming in direction and dip to those in that direction in Connecticut; but it is scarcely probable that it is *in place*, as rock has not been found distinctly *in place* on the island, except near Hurlgate, and it is not larger than a great number of the blocks overlying the tertiary sands and clays of Long island. The part above ground would weigh perhaps two hundred or three hundred tons. Pebbles were abundant on this ridge, but no other rocks were seen.§ Boulders are abundant on the hills south of the road between Coram and West Middle island.

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* Vide page 33 of this volume.

† In the northwest part of Riverhead near Wading river, boulders were observed in abundance in the hills. They were mostly granitic, with some of gneiss and greenstone.

‡ About three miles east of Moriches, the fragments of a large boulder were seen by the road-side. It was a reddish contorted gneiss, precisely similar in appearance to a granitic or gneissoid rock that abounds between Groton and Norwich, and in New-London and Montville in Connecticut. The rock is not fissile, but the mica and other materials are arranged in curved and contorted lines and layers.

§ The ridge was mostly covered with trees and brush-wood at that time.

At and about Wading river, blocks and boulders are found in the greatest profusion. One block that had been blasted in pieces for walls, gave one hundred cart loads, and many others were seen still larger. One block of gneiss at Wading river was a singular one, and may be considered as adding another fact in the chain of evidence, tending to show that gneiss is but an altered sedimentary rock, formed as the sandstones have been, and as beds of sand now are. A sketch to illustrate the lamination may be seen in Plate 36, fig. 4.

On the beach a little west of East brook, or a little more than a mile from Wading river, a block of fine-grained limestone containing serpentine was found. It was precisely similar to the New-Haven verd-antique marble. Greenstone boulders and blocks were not rare in the same vicinity; and at two miles west of East brook, a block of trap was seen on the beach, that contained at least one hundred cubic yards.

Between Miller place and Old Man's, the surface is pebbly, with blocks and boulders of gneiss and granite. Near Old Man's, the hills are steep, and elevated about one hundred to one hundred and twenty feet above tide water, with a light loamy soil. On the lower level, pebbles and blocks are numerous. Many blocks of one hundred tons or more each were seen; and in one place half a mile east of Old Man's, is a nest of five or six of these enormous blocks, which, but for their lines of bearing and dip varying very much in the different blocks, would almost lead one to suppose that a similar rock was in place just beneath the surface. One block of gneiss on the road leading to a house at the head of a small cove, three-eighths of a mile east of Old Man's, was smoothed on one side, and was also scratched like the diluvial grooves and scratches often seen on rocks *in place*. The part on which this smoothed and scratched surface was exposed, had been recently uncovered of earth. The part that had been above ground, was weathered and rough.

Only a few boulders of greenstone, and a single one of red sandstone, were observed in travelling from Miller's place to Smithtown.

Fragments of a block of porphyritic granite were observed near Setauket, similar to that in the vicinity of Reading, and of Sterling and Killingly in Connecticut. It had been blasted, and made into a wall.

In Smithtown, about half way between the village and Stony brook, a boulder of about two tons weight was observed, composed of a coarse siliceous conglomerate with a siliceous cement. It resembled some of the coarse conglomerated coal grits of the coal region of Pennsylvania, the conglomerate grits of some of the peaks of the Catskill mountains, of the Shawangunk mountains, and some of those about Boston (Mass.) and Newport (R. I.). There were no distinctive characters by which I could refer it to its parent source. The pebbles in it were from the size of hazlenuts, to a six pound shot.

Some boulders were seen on Mount Pleasant, but they were not abundant. This swell of ground is elevated about one hundred feet above the Smithtown valley, and in the whole of that valley a single boulder was not observed.

In Huntington, at Dix hills, four miles west of Commac, the same character of hills is observed as at the Shinnecock and Montauk hills, namely, they are small, round-backed,

composed of gravel, pebbles and boulders, with numerous small pond-holes in the depressions between them. A boulder of serpentine, containing diallage, was seen on the road-side between Commac and the toll-gate on the road towards Dix hills.

Ferruginous conglomerate, in pebbles and small boulders, and a ferruginous sandstone with limonite as a cement, are common in the hills that begin on the west side of the Smithtown valley, and extend to Huntington. Fossil wood was found in some of the masses of brown iron-stone and ferruginous sandstone.* A single large pebble, or small boulder of brown iron-stone, was found with the iron-stone containing the petrified wood, three miles northwest of Commac.

Red granite, white granite, gneiss, slaty hornblende rock, and a kind of sienite composed mostly of hornblende, such as is frequently called primitive greenstone, are common as boulders and pebbles between Commac and Huntington. The hornblende slate and primitive greenstone strongly resemble those in the vicinity of Lantern hill in North-Stonington (Con.), and the range of those rocks north. There *may* be similar ones west of New-Haven, that I have not seen.

On Lloyd's neck in Huntington, granular white limestone and dolomite, hornblende slate, hornblende rock, granite, porphyritic gneiss and common gneiss, were seen among the boulders and blocks, both in the drift deposits, and on the shore where they had been washed out of their former position. Granite, gneiss and trappean rocks are the most abundant among the boulders.

On West neck in Huntington, the boulders are rather common; and among them, granite, gneiss, porphyritic gneiss, trap, and hornblende slate are the most common.†

The country between North-Hempstead and Jericho, except within a mile and a half of the latter place, is a part of the Hempstead plains, and is like almost all the portions of Long island south of the range of hills, sloping almost insensibly to the eye from the hills to the ocean, and composed mostly of sand loam and gravel. Near Jericho, the road leads into the swells of the hills; and these are, like those of the chain of hills stretching through the island, composed of loamy gravel, with an abundance of pebbles and boulders. The red iron-stone, brown iron ore, and ferruginous conglomerate, were seen more abundantly between Jericho and Oysterbay, than in any other part of the island. The boulders and pebbles consist mostly of granite, gneiss, quartz rock, mica slate, talcose slate, chlorite slate, with some hornblende rock; and the latter is massive, laminated and fibrous in texture. The mica slate, talcose slate, and chlorite slate are rare. A few boulders of serpentine containing anthophyllite were seen one mile south of Norwich, on the east side of the road, among loose stones that had been collected from the fields to make a stone fence.

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* This was petrified wood, converted to limonite by the hydrated peroxide of iron replacing the ligneous fibre. I was not deceived in this matter, for I am perfectly familiar with the numerous aspects of fibrous limonite.

† Prof. Briggs saw a boulder of sparry limestone, and two others of white granular limestone, on the shore, about a mile east of Fresh Pond creek.

A point of loose blocks and boulders may be seen at low water, three quarters of a mile east of Fox island, in Oysterbay township, the remains of higher land that has been washed away. The beach extends back of it, and a narrow neck of the upland that once communicated with it extends back from the beach. A marsh and sand beach connect this neck with Oak neck, which was once an island; an extension of the same beach unites the latter with Hog island, or Middle island, as it is now called. Oak neck is washing away, the materials being swept eastward or westward, according to the direction of the waves and shore currents. A belt of boulders and blocks extends seaward, that may be seen at ebb tide. On the north shore of the Middle island, at and near Rocky point, the cliffs of drift are high; and as it is washing away, great numbers of blocks and boulders line the beach, and extend seaward from one quarter to half a mile. These may be seen at low tides. The same remarks may be made of Martinecock point, where boulders also extend some distance seaward.

Granite, gneiss and hornblendic gneiss were the principal rocks seen among the boulders and blocks of the north coast of Oysterbay township; but on the north shore of Oak neck, blocks of granite with yellow feldspar (almost lemon yellow) were observed. I have never seen such granite as this in place, and its peculiarity may aid in tracing the blocks to their original locality, probably in Connecticut or Westchester county.

Blocks and boulders extend out also at Kidd's point, Sand's point,* Barker's point, Hewlet's point, the Stepping Stones, and generally along the projecting parts of the northwest coast of North-Hempstead, on all of which the shore is wasting away more or less rapidly.† Kidd's rock has long protected the shore at this point (Kidd's point);‡ while the shore on each side has been more rapidly removed, forming receding curves on the coast; but the earth is so much removed around this mass of rocks, (the waves rushing among its fragments and removing matter at every tide,) that it cannot be many years before it will disappear beneath the water, as the other rock has done that was also called Kidd's rock.† The erratic block, now cracked into fragments, and called Kidd's rock, is a group of huge blocks of hornblendic gneiss, some of which will weigh several hundred tons. Epidote is found in many of its fissures. It is very similar in its mineralogical characters to some of the hornblendic gneiss of the Highlands about West-Point and Bull hill, and also a part of Westchester county.

The surface of the north part of North-Hempstead generally, where it is not covered with alluvial or quaternary deposits, exposes great numbers of boulders and blocks, varying in size from a few pounds to several hundred tons weight.

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* At Sand's point, granite, gneiss and hornblendic gneiss were the most common rocks constituting the boulders; but a few of trap, of red sandstone, and of white granular limestone were observed. A single boulder also occurred of white quartz pebbles, cemented by iron pyrites. It was greenish and reddish on the exterior, in consequence of the partial decomposition of the pyrites. I have never seen rock precisely similar to this, but in one locality, *in situ*, and that is on the Shawangunk mountains in Ulster, where the pebbles of one of the strata of the Shawangunk grit rock are cemented by pyrites. A specimen, now covered with a down of acicular crystals of sulphate of iron, from this boulder, may be seen in the case containing the boulders of Long island in the State Museum at Albany. Boulders of the same were found in Orange county.

† Vide Encroachments of the Sea, pp. 22 and 23 of this volume, where this erratic block is described.

‡ Vide Plate 2, fig. 1.

About half or three quarters of a mile from Plandome, on the road to Hempstead court-house, is an enormous block of granite, undoubtedly an erratic block, which was estimated by the eye to contain eight hundred cubic yards above the surface of the ground, and must weigh near two thousand tons. Blocks like this, of fifty to five hundred tons weight, are not uncommon; but this block is the largest I have seen that was solid, and had not been cracked into fragments by natural causes. This block may be the same described by Dr. Mitchill? in Bruce's Mineralogical Journal, as containing 20,400 cubic feet.*

About two and a half miles north of Plandome, on the shore of Cow bay, I found a large block of tremolite containing pargasite and talc. It had been blasted for making a stone fence. It is somewhat similar to a rock found at Warwick and Edenville, Orange county. A specimen may be seen in the case containing the drift of Long island, in the State Museum at Albany.

Granite and gneiss form the largest portion of the boulders and erratic blocks of Great neck, in the northwest part of North-Hempstead. Much of the gneiss is hornblendic gneiss, and the hornblende may be considered as the basis, it being the predominating ingredient. In some of these masses, granular epidote is very abundant, forming nearly one-half the mass, and its proper descriptive name would be *epidotic hornblendic gneiss*. A large nest of these blocks, containing perhaps one hundred tons, may be seen at high-water mark, on the north-east shore of Great neck, near the outlet of a salt pond. Another nest of hornblendic gneiss blocks, (which may possibly be in place,) may be seen at high-water mark on the north-west shore, near Hewlet's point. Boulders of tremolite, like that on Cow neck, were seen in several places on Great neck. Boulders and blocks of white granular limestone, like the Westchester limestone, were observed on the northwest shore, between Hewlet's point and the ferry. Some of them contained an abundance of white tremolite, in bladed crystals and large masses.

In Flushing township, boulders of greenstone trap predominate from Flushing to Little-neck bay. Two miles from Flushing village, on the road to Little-neck bay, some small boulders of serpentine were observed. Three miles from Flushing, many boulders of grey sandstone, with grains from the size of mustard seed to gravel, were noticed. They are composed of grains of quartz and feldspar, most of which are rounded, and the latter are in a state of decomposition, forming white, pulverulent or crumbling grains, which give a whitish color to the masses of rock. This rock slightly resembles a crumbling feldspathic granite, for which it has been sometimes mistaken. Dr. J. E. DeKay, the Zoologist of the Geological Survey, informed me, that a rock of precisely similar aspect underlies the trap rock of the Palisades, at or near Bull's ferry, on the New-Jersey side of the Hudson. It probably belongs to the red sandstone formation underlying the trap.

At two and a half miles from Flushing, a large boulder of greenstone was observed on the south side of the road. It was covered with "diluvial" scratches.

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* Bruce's Mineralogical Journal, Vol. 1, p. 132. I have the reference, but not the book, and there is no library in this vicinity that has a copy of the work.

About a mile southwest of the head of Little-neck bay, on an old road that runs east and west, on the north side, are some large slaty masses of erratic rocks; they are composed of talc and anthophyllite. One fourth of a mile farther east, a boulder of serpentine and anthophyllite, weighing a ton or more, was observed; the serpentine was of a fine green color. Boulders of trap were numerous, mixed with some of granite, gneiss, etc. on the hills around, and in the ravines that enter the valley at the head of Little-neck bay.*

North of Flushing, on Lawrence neck and at Whitestone, boulders and blocks are very numerous, composed principally of gneiss, granite, trap, and hornblende rocks. One kind of boulder common there, and to which Whitestone probably owes its name, is what appears like a decomposing granitic rock. The rock is light colored, almost white, from the feldspar decomposing to form kaolin. After examining many specimens, I could scarcely satisfy myself whether it was a granitic rock, or a recomposed rock of the materials of granite. It is nearly similar to that described as three miles from Flushing on the road to Little-neck bay, and may probably have the same origin.

In Newtown, trap boulders predominate in the loam and gravelly loam of the hills on the Jamaica road from Hallet's cove (now called Astoria), and also on the Flushing turnpike.

The Jamaica hills, which skirt the great southern plain of Long island a little north of Jamaica village, have the same general characters as the Montauk, Shinnecock, and Dix hills; that is, they are very irregular round-backed hills, with many boulders and pond-holes. The soil of these hills, however, is richer, in consequence of the partial decomposition of a different class of rocks, that *predominates* in the detritus. Among the boulders observed in these hills were greenstone, granite, gneiss, mica slate, hornblende rock, sienite, talcose rock, red sandstone, red quartz rock, white siliceous conglomerate, limestone and serpentine. Greenstone is by far the most abundant, and all are more or less rounded. The masses vary in size from a few pounds to many tons weight.

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* At the foot of the hill near the marsh, on the road from Flushing to Little-neck bay, the road is cut through a bed of shells of the common oyster (*Ostrea virginica*), and round clam, covered by about one foot of earth. They lie in a black mud, similar to that in which oysters live, but dissimilar to the habitat of the round clam (*Venus mercenaria*). The bed is four to six feet above the highest tides. This would perhaps be pronounced an example of elevation of the land since the testaceous animals lived; but it is more probable that it is the location of some Indian wigwam or village, and the wash of the hills has since covered the bed of shells. Not a single pair of valves was found united, as some of them would be if they had died as they are found, or if it had been the natural oyster bed. Even had some few been found, they would not invalidate the evidence; as dead shells of oysters, with the valves closed, are often brought up from the beds and sent to market, and it is probable that they were also brought to their villages by the aborigines.

I have seen a great number of localities of shells on Long and Staten islands, and on the shore of Connecticut, and the case above mentioned is the one that carries the strongest evidence of their being fossil, of any I have seen; but there are two objections that seem to my mind to be conclusive, even in this case: First, the material in which the shells lie, being different from the proper habitat of one of them, namely, the Venus mercenaria; and secondly, the valves all being separated.

Many of the shell beds in various parts of the island contain the common scollop shell (*Pecten concentricus*), the *Mytilus edulis*, and the *Pyrula canaliculata*. They are all such testacea as have been used by the aborigines, and still are to a greater or less extent by the present inhabitants of the island, as articles of food.

The materials just mentioned also constitute the mass of the hills from Jamaica to Williamstown and Brooklyn. The excavations at Williamstown, and the stone fences for six miles towards Jamaica, show the boulders to great advantage.

At Brooklyn, on the heights back of the Navy Yard, where extensive excavations were being made for grading streets in 1837, the boulders imbedded in gravel and loam were observed to consist mostly of greenstone, from a highly crystalline to a perfectly compact fine-grained texture. Granite, gneiss, and red sandstone boulders and blocks were common. The boulders and blocks are often large masses, from five to twenty or more tons weight, lying on and surrounded by loam or sandy gravel. Some of the boulders showed "diluvial" scratches.

The upper soil at Brooklyn is generally a yellowish sand and sandy loam; below is a loam and gravel, containing great numbers of boulders, blocks and pebbles. Below the boulder bed is a series of strata of sand, gravel and clay, in which shells are said to be frequently found, but I saw none. Some of the streets that were being graded, were twenty to fifty feet in some places below the original surface of the earth, and exposed to view fine sections of the strata. Greenstone, serpentine, red sandstone, granite, gneiss, etc. form the mass of the gravel and boulder beds.

Between Flatbush and Brooklyn, the country is sandy gravel and sandy loam, like all the great southern plain of Long island to the base of the hills. Soon after beginning to ascend the hills, Prof. Merrick found some small fragments of shells in a gravel bank, where excavations had been made for sand. It was in the woods, near the tavern, at the head of the road. The fragments were very small and water-worn, and too imperfect to determine their species. From thence to Brooklyn, the surface was loam and pebbles, containing great numbers of boulders, which were principally greenstone.

Between Jamaica and Brooklyn, on the line of the railroad, the excavations show the soil of the plain to consist of sand and gravel, in some places rather loamy, usually of a light yellowish color, from the intermixture of the hydrated peroxide of iron. A little west of East New-York (a paper city five miles east of Brooklyn), the railroad enters the range of hills, and is excavated for a considerable distance from ten to thirty feet. The materials excavated consist of loam and "hardpan," containing multitudes of boulders, blocks, and pebbles of greenstone, granite, hornblende rock, gneiss, red sandstone and serpentine. The same characters of soil and boulders continue to Brooklyn.

The hilly region from Brooklyn to Bedford, and thence to Flatbush and Bath, are similar to that described, as also the plains of Flatbush, like the rest of the great plains of Long island. About one mile west of Bath, in New-Utrecht, boulders of greenstone are very abundant, with some black serpentine and red sandstone; and these, with a heavy loam and some gravel, form the soil of the country around. This place is where the range of hills of Long island is intersected by the shore. This range of hills is nearly straight in its general direction to Flushing and Newtown, where it curves around by Williamsburgh and Brooklyn, to Fort Hamilton and Fort La Fayette, at the Narrows; and the same range of hills is con-

tinued on Staten island, for a short distance from Forts Tompkins, Richmond and Hudson, but in a few miles it mostly disappears below the quaternary sands.

The loam in which the pebbles and boulders are imbedded, is reddish about Bath and thence on towards Brooklyn. Shells are said to have been dug up in almost every well in this hilly range, but I could find none, nor obtain a sight of one at any locality where they had been found.

The boulders abound from Fort Hamilton to Yellow-hook. I crossed the hills in various directions, and the character was uniformly the same, namely, loamy soil, with many boulders of trap, and some of serpentine and red sandstone like those of Hoboken and the adjoining trappean range, and granite and micaceous gneiss like those of the island of New-York.

Above Gowannus, in the lower part of Brooklyn, a fine section of strata was exposed where they were cutting through the grade of —— street, at a depth of forty to fifty feet. The strata of gravel and clay were very much contorted in one locality, showing distinctly the action of a disturbing force, ranging nearly east and west. A little north of this, the corresponding strata, which were of a yellowish brown clay, interlaminated with very fine sand, were horizontal. Shells were said to have been found here; but although I examined the stratum very carefully in which they had been found, I saw no traces of any. They were said to have been found between the sand and clay strata, which alternate in thin layers.

The discussion of the subject of the shells will be deferred until the tertiary strata shall be described, as they are supposed to belong to that formation.

Plum island, Gardner's island, Gull island, Fisher's island, City island, Hart's island, Barn islands, the Brothers, Riker's island, etc., all contain an abundance of boulders and blocks in a formation similar to those of Long island; and as their drift deposits are very similar to those of Long island, and would give no *additional* evidence of importance bearing upon the northwardly origin of the drift, it is considered superfluous to adduce localities and minute descriptions from *them*.

The drift deposits form the surface and shore of a part of Staten island. At the Quarantine, this deposit contains boulders intermixed with sand and loam overlying granite.*

At New-Brighton, boulders were exposed in great numbers in grading the streets. Between the Quarantine and Fort Tompkins, deep and fine sections were exposed in grading the streets of a premature city. Greenstone is the predominant rock; but granite, gneiss and red sandstone, are very common. The whole soil, in fact, is red, in consequence of a large portion of its materials being derived from the red sandstone. The strata containing these materials show the action of water in their deposition, not only in the rounded form of the pebbles and boulders, and the scratched surfaces of some of them, but in the water lines of deposition, showing the lamination oblique to the stratification, as we see in sand and gravel beds forming at the present time. Boulders of serpentine, and the peculiar granite or sandstone described at Whitestone and three miles east of Flushing, occur mixed with the more common ones before described.

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* Granite rock in place was visible in 1837, on the shore in front of Nautilus Hall at the Quarantine.

A boulder of limestone, weighing a ton or more, was dug from a well in the hilly region (the gravel and loam hills of drift) of the interior of Staten island, from a depth of about sixty feet. It was replete with fossil shells, and was similar in chemical composition, mineralogical structure and texture, and in its fossil remains, to one of the strata of the Helderberg limestone series, and which extends from the Helderberg mountains west-southwest of Albany, in a southeasterly direction to near Coxsackie, thence south to Kingston, thence southwest through the Mamakating valley to Carpenter's point on the Delaware. This belt of rock, and an outlier of the same at Hudson, are the only rocks of the kind known so near, except in a westerly direction across the mountain ranges on and beyond the Delaware river. A specimen of this rock is preserved in the State Museum at Albany.

In the interior of Staten island, a boulder of limestone filled with fossil shells, and similar to that of Becraft's mountain near Hudson, was dug from a well at a considerable depth. A boulder of siliceous limestone, like one of the strata of the Helderberg, containing fossils, was dug from another well on Staten island. These boulders were seen by Mr. Hazzard, who gave me specimens of these blocks, which he had preserved. I found a small boulder of decomposed rock on the shore near the southwest light-house, filled with fossil remains similar to those of the middle limestone of Becraft's mountain, Columbia county. Dr. James Pierce describes petrifactions of marine shells in rocks excavated on Staten island, twenty feet below the surface, and sixty above the ocean.*

The city of New-York is built partly on the drift deposits (particularly the northern), and other portions on the quaternary, alluvial and primary. The drift deposits are daily exposed to observation by digging wells, foundations of buildings, grading streets, and cutting down the hills to obtain materials for filling up the lower ground and marshes. The materials of the drift consist of boulders, pebbles, gravel, sand and loam, composed of granite, gneiss, sienite, mica slate, hornblende rock, crystalline and compact trap, serpentine rock, steatite, red sandstone, grey grits of the Hudson slate series; white, blue, grey, compact and crystalline limestones of various geological ages, some of which contain fossil remains; and slate of various kinds, as blue, red, green, talcose and chloritic.

The above mentioned rocks I had observed as boulders in 1828–9. Prof. L. D. Gale was employed in 1838 to make a geological examination of New-York island; and as his observations have been more minute than my own, I will quote him on the boulders. I consider his observations very important, in consequence of the strong evidence they afford on the point under investigation; and although there are some local irregularities in the direction of the distribution of the boulders, it is believed that they will all harmonize, when all the facts shall have been brought forward that have been observed.

Prof. Gale, speaking of the boulders of New-York island, says:

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* Silliman's Journal, Vol. 1, p. 145.

"The following are the principal varieties of rock:

1. Greenstone in all its varieties.
2. Red and grey sandstone, and their varieties.
3. Serpentine like that at Hoboken.
4. White primary limestone, like that at Kingsbridge.
5. Granite and gneiss, like that found on the island.
6. Hydrous anthophyllite, like that found in place on the west side of the island.
7. Greywacke, like that found in the valley of the Hudson above the Highlands.
8. Limestone like that of Catskill.
9. Ferruginous sandstone or jasper rock, like the sandstone underlying the Palisades near Fort Lee.
10. Clay stone, supposed to be from the same source as the last.
11. Actynolite, supposed from the anthophyllite locality.
12. Kyanite: this has been found in small fragments, but I am not aware that it has been traced to its locality.

"The abundance of the several varieties of rock above enumerated, is very different in different parts of the island. While some are common to every section, others are confined to a particular part; thus, greenstone is found in boulders every where from north to south, and from east to west; while serpentine, like that at Hoboken, is confined to the southern limits. The details of these facts will be found below:

1. *Greenstone.* This in all varieties is perhaps the most abundant rock that is not found in place on the island, yet in boulders is common to every part of it. In almost every instance, they are worn to a rounded form, though it is one of the hardest and toughest rocks known. They are among the largest transported rocks on the island, being from ten to fifteen feet in diameter, and often covered with grooves and scratches indicating the mechanical violence to which they have been exposed. This rock is not found in place on the east side of the Hudson, but is the chief rock on the western shore, from Tappan bay on the north to Bergen hill on the south; and as all the varieties found in place there can be selected amongst the boulders here, the necessary inference is, that this locality is also the source of the greenstone. Specimens are in the State Museum.

2. *Red sandstone,* like the greenstone, is common to every part of the island, being found from Corlear's hook to Kingsbridge, but most abundant towards the former place. These boulders vary considerably in appearance, as well as in size. Though occasionally consisting of coarse pebbles, they are generally fine grained, of a red or greyish red color, and distinctly stratified. I have found some that measured nine or ten feet in diameter. This rock, like the greenstone which it accompanies along the Jersey shore, is not found on the island, nor on the east side of the Hudson nearer than the valley of the Connecticut. There are two other varieties which I have referred to the red sandstone formation, but on account of their peculiar character as boulders, I will describe them by themselves under the name of ferruginous sandstone and claystone. Specimens are in the State Museum.

3. *Serpentine,* like that at Hoboken, is common in the southern, but rare in the northern parts of the island. In speaking of serpentine, we shall make a distinction between that variety found in place at Hoboken, and that found at the anthophyllite locality on the island, which approximates to serpentine in character, but is harder, and is mixed with limestone. These boulders are much more common in Brooklyn than in this city, except perhaps the region of Corlear's hook. This might be expected, taking for granted that they were transported from Hoboken, which seems to be a necessary conclusion, as no other locality of this variety is known in the vicinity. Besides, the direction of the diluvial grooves being from northwest to southeast is such as would carry the materials from Hoboken to Corlear's hook, and the east part of Brooklyn.

4. *White* or *Primary limestone.* Boulders of this material were found some years ago in cutting away the hills at Corlear's hook, and in a number of places on the east side of the island, between the city and Kingsbridge; but I have neither seen nor heard of any being found on the western side. The principal places where I have found this rock, are on the Fourth avenue near 120th-street; at the Seventh avenue, north of the village of Harlem, near 142d-street; at McComb's dam, at the northern termination of the Seventh avenue; and in a number of places in the valley of the Harlem river, between McComb's dam and Kingsbridge. Now the nearest locality where this rock is found in place, is at Kingsbridge, and I have no doubt that the boulders in question came from this place; but had they been transported in the general direction of the current shown to be northwest and southeast, instead of reaching their present location, they would have been carried across the Harlem river, and have been deposited in the range of grounds lying about midway between Harlem and Westfarms. Specimens are in the State Museum.

5. *Granite* and *gneiss,* especially the latter, being abundant in every part of the island except the northern extremity, boulders of these might be expected to be more numerous than of any other materials; yet I think greenstone boulders are quite as numerous, take the whole island together, as granite and gneiss. The largest boulders I have seen of the latter kind measured in diameter twelve and eighteen feet, and are equally common in all parts south of the Harlem and Manhattanville valley. The granite, which exists in veins in the gneiss, is mostly on the west side of the island; and this when torn from its place and transported by a northwest current, would naturally have been distributed over the eastern parts, and even as far as Long island. A number of very large ones were excavated between 1825 and 1830, in the vicinity of Corlear's hook, some of which were peculiar in character. One I well remember lay many years on the south side of East-Broadway, near its junction with Grand-street. It was a grey granite of coarse texture, with tabular crystals of black hornblende three or four inches in diameter interspersed throughout. It was eighteen feet long, sixteen broad, and eight and a half high. This is the largest boulder I have seen on the island, but those from ten to twelve feet diameter are very common.

A large boulder of granite, eleven feet in diameter, and though somewhat rotund, has a rough and angular surface, as though it had suffered little from mechanical violence, rests on the gneiss rock on the east side of Bloomingdale road, from a quarter to a half a mile south

of the village of Manhattanville, and at the southwest corner of a Mr. Stevens' house, between it and the road. The whole rock on which it rests is covered with diluvial grooves; and a very large one three inches deep and eighteen wide, between the road and the boulder, and terminating at the latter, seems to have been the result of the movement of this huge mass. Specimens are in the State Museum.

6. *Hydrous anthophyllite.* This rock has been familiarly known for many years in this vicinity under the name of *radiated asbestos rock,* but was known only as a boulder found in considerable abundance in various parts of the city, and as far north as Fifteenth or Twentieth-street. Its geological place was not, however, known at that time; and as its true mineralogical character was somewhat doubtful, Dr. Torrey sent specimens of it to Professor Thomson of Glasgow, who analyzed and pronounced it anthophyllite; but as it contained a much larger proportion of water than had usually been found in this mineral, Dr. Torrey proposed to prefix the term *hydrous,* which has been generally adopted.

This rock has been found in place on the west side of the island, between Tenth avenue and the Hudson, and between Fifty-seventh-street on the south, and Sixty-third-street on the north. Here the strata are nearly vertical; the strike is north-northeast; the width of the bed at right angles to the strike varies from three to thirty rods. It commences at Fifty-seventh-street, within thirty or forty feet of the avenue, and runs obliquely to the streets, crossing the Eleventh avenue near Sixtieth-street, and runs out at the river on Sixty-third-street. It is remarkable that the granite lying on the west, and the gneiss on the east of the rock in question, come in complete contact with it without intermixing. So remarkable is the line of separation on the side next to the gneiss, where there is the best opportunity to examine the two, that within the space of three inches each rock possesses all of its own peculiarities, with none of those of its neighbor. The mineral character of this rock varies much in different parts of the bed. In the southeast portion, where it approaches nearest to Tenth avenue, it exhibits little or no stratification, is very dark colored, and has a tabular structure. In the same vicinity are found masses of serpentine and limestone intermixed, exhibiting a porphyritic appearance, the serpentine appearing green and the limestone white. Again near the middle of its course, or near where it crosses the Eleventh avenue, it becomes lighter in colour, more fibrous and scopiform in structure; but the fibres are large, and in some instances approach the character of actynolite. Still lower down, following the strike towards the river, the same mineral character continues, except that the fibres are still firmer, and the whole texture becomes softer and more like steatite; so that many years ago, before the rock was known to geologists, it was attempted to work this bed for a soapstone quarry, to be applied for similar useful purposes; but the material being too hard, the project failed.

This rock has been found in boulders in all of the southern part of the island, and some are very large. On the west side they extend from the rock in place to Fifteenth-street. In the middle division they have been found from Forty-eighth-street on the north to Fourteenth-street on the south, and on the east side from Twenty-fourth-street to Corlear's hook.

On the south side of Fourteenth-street, between Bowery and Third avenue, is a boulder of this rock fifteen feet long, twelve broad, and six high, containing on its surface abundance

of diluvial scratches running longitudinally. Again, thirty feet west of Third avenue, on the south side of Sixteenth-street, and forty feet distant from it, is another boulder, thirteen feet long, eight broad, seven high; it is uniform in texture like that on Sixty-third-street, in place, and is covered with scratches running longitudinally. Another twelve feet long, eight broad, and eight high, is lying in Twenty-fifth-street, about twenty rods west of Fourth avenue, covered with scratches in every respect like those of the last.

Now had these boulders (which, I doubt not, have all been derived from the same rock,) followed strictly the course of the current indicated by the diluvial grooves on the island, they would have been found along the Bloomingdale road, near the Eighth avenue, and from thence eastward to Kipp's bay and the Alms-house, and possibly somewhat lower down; instead of which, they have been carried much farther south, to Corlear's hook, and even on Long island.

I will here remark, that I strongly suspect that there are other localities of this rock eastward of this island; for boulders of the same character, resembling most perfectly specimens of this island, have been found at West-farms, New-Rochelle, and Sawpits, which could scarcely have been transported from the locality on this island.*

7. *Greywacke*, which is common in the valley of the Hudson. I have seen specimens found many years ago, in grading the streets at Corlear's hook. These specimens closely resemble the rock brought to this city for the purpose of flagging the sidewalks, from Coeymans and Coxsackie, also from Esopus creek; but as no specimens have come to my observation recently, or since about 1830, I cannot speak from personal knowledge.

8. *Limestone, like that of the Catskill or Helderbergh mountains*, abounding in *Productus*, has been found at Corlear's hook, and in other places in the southern part of the island. I have a single specimen in my cabinet, obtained at that place in 1826, at the depth of forty feet below the natural surface. It was then a boulder two or three feet in diameter, and has been distributed so that but a small fragment now remains. I discovered it, and removed it to my cabinet, and considered it as bearing such strong evidence of its source, that I shall forward it to be preserved in the State Cabinet at Albany.

9. *Ferruginous sandstone*, or *Jasper rock*, like that found in place underlying the Palisades, near Fort Lee.

This rock, which is one of the most abundant next to greenstone and granite, in the south part of the island, I have not found north of the Harlem and Manhattanville valley. It is most abundant between Thirteenth and Twentieth-streets, and between Second and Fourth avenues. This rock, when first noticed, was supposed to be a ferruginous quartz in a state of disintegration; but on a closer inspection, an obscure appearance of stratification was observed, and the component grains were found rounded and often transparent, and cemented together by a large amount of oxide of iron. In some specimens it is difficult to identify the granular structure on account of the abundance of the cement, and the advanced stage of decomposition in which it is found; in others, there is so intimate a union between the

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* Vide Boulders of Westchester county.

parts that the whole seems to be one entire mass. There are others, again, where the cement puts on the appearance of jasper, and hence the name of jasper rock, which has frequently been applied to it.

In searching for the geological place of this rock, I am satisfied I have found it underlying the Palisades in the neighborhood of Fort Lee, where the red sandstone comes out under the Palisades very near the water's edge, and exhibits a great variety of character. Specimens of this rock are in the State Museum.

10. *Claystone*, supposed from the same formation as the last; they are distinctly stratified, and have a clay color. They are often quite hard and slaty in structure. Specimens of this rock are in the State Museum.

11. *Actynolite*, supposed from the anthophyllite locality. This variety has been found in boulders at Corlear's hook, and in other places in the southern part of the island. One of three or four feet in diameter was discovered in 1826, near the corner of Monroe and Montgomery streets. I preserved a single specimen, and remember distinctly the character of the whole mass; and on comparing the specimen in my possession with the varieties of anthophyllite in place, I doubt not that all the specimens of actynolite on the island have been transported from this source.

12. *Kyanite*. All the specimens of this rock that have come to my knowledge were in loose fragments, lying on the surface, inferior in quality. I found two specimens in 1826 near Kipp's bay, but have heard of none more recently, nor have I been able to trace it to its geological place."*

In Westchester county, between Harlem and Westfarms, boulders and blocks of greenstone like that of the Palisades, granite and gneiss with some mica slate, are thickly strewed over the ground in many places.

Between Kingsbridge and Yonkers or Philipsburgh, boulders of trap are abundant, precisely similar to that of the Palisades; and no other trap is known, *in place*, east of the Palisades, nearer than that of Southbury and New-Haven in Connecticut. About Bedford, Prof. Cassels observed many boulders of a granitic porphyry.

Boulders of serpentine, containing radiating fibres of anthophyllite, were observed in the southeast part of Whiteplains; in the south part of Harrison, and in Mamaroneck. One mass was observed near the road from Whiteplains to Mamaroneck, that must weigh sixty to one hundred tons. Prof. Cassels mentions a large mass of this rock by the road-side, one quarter of a mile east of Westchester court-house in Pineplains, on Mr. Crawford's farm, and which he thinks is *in place*. Another locality of this rock *in place*, is reported three or four miles south or southeast of Pineplains. I did not see it, but had inferred the existence of this rock *in place* in those parts of Westchester county, by observing the boulders; and as there is but one locality *definitely* known, namely, that on New-York island described by Prof. L. D. Gale; and as boulders in the part of the country under consideration are not known to have

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* Geological Report of New-York, 1838, pp. 190, 196.

been observed in a *northwardly* direction from their original position, but almost uniformly are found in a *southwardly* direction, this inference necessarily followed.

Westchester county is almost covered by the drift deposits, though perhaps few counties show rocks *in place* more abundantly. The boulders can almost all be referred to the parent sources at no great distance, in a northwardly direction. At Peekskill, these deposits may be seen well developed. The small stream has excavated a valley in the boulder and gravel beds between the village and landing, from fifty to one hundred feet deep.

In Putnam and Orange counties, a great variety of boulders, pebbles and erratic blocks are found. In the mountains the boulders are mostly of the same rocks as those of the vicinity in a northwardly direction, except on the northern flanks of the mountains, and in the deeper valleys, where the rocks from a great distance to the north abound. In the valley of the Croton, which communicates on the north with that of Oblong creek, through the Dover and Ancram valley, many of the boulders are of the talcy slate containing quartz veins, like that of Taghkanic, Hillsdale, Austerlitz, Chatham, Canaan and New-Lebanon. The Fishkill and Coldspring valley contains boulders and pebbles of all the varieties of the Hudson slate rocks, and the Taghkanic series that occur in the Hudson and Champlain valley, as far north as Whitehall. The Potsdam sandstone is the hardest of these rocks except quartz, and the pebbles of these two rocks are most abundant. The Potsdam sandstone pebbles are like the sandstone of Whitehall and Fort-Ann, and the quartz is mostly like that in veins in the slaty rocks in Hillsdale, Taghkanic, Canaan, Austerlitz, Chatham and New-Lebanon, in Columbia county; being generally white milky quartz, frequently containing chlorite, brown spar, and sometimes carbonate of iron, carbonate of lime, and quartz crystals. The brown spar is frequently decomposed, leaving earthy oxide of manganese in the cavities. The aspect of this quartz, together with the association of minerals, is so *peculiar*, as to leave no doubt of the parent source of these pebbles.

The valley of the Hudson river through the Highlands, shows boulders, blocks and pebbles of all the rocks of the Hudson and Champlain valleys, and of the Mohawk valley, that would not easily grind up by attrition. They occur from the level of the river to a height of about a thousand feet, and some few perhaps are found higher; but they are very rare above that height, and are most abundant at an elevation of three hundred to five hundred feet.* The plain of West-Point, which belongs, in part at least, to the drift, is an instructive example of these deposits. In the gravel, pebble and boulder beds at that place, a person may collect a suite nearly complete of all the rocks, and many of their minerals and fossil remains, that are found in place for a distance of two hundred and fifty miles to the north. Primary rocks like those of the Highlands, consisting of granite, gneiss, sienite, hornblende rock, hornblendic gneiss, granular limestone, verd antique and augite rock, are most abundant. The rocks belonging to the Hudson slate group, as hard grey grits, such as have been called greywackes, often traversed by veins of quartz, and sometimes by those of calcareous spar and

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* These heights are *estimated* by the *eye*, not measured.

satin spar; slaty rocks of various textures and colors, as fine-grained slaty grits; slate like roofing slate, of a blue colour, others red and mottled, coarse and fine; and siliceous slate and basanite, are those that rank second in relative numbers. Limestones like the various limestones and calciferous rocks of all the Hudson valley, blue, grey, black, compact, crystalline, and fossiliferous; conglomerate like that of the Shawangunk mountains; opalescent feldspar rock like that of Schroon in Essex county, and pebbles of the Potsdam sandstone, are next in relative numbers. Specimens of these rocks can all be referred to their proper strata, without much chance of error, and all are evidently and undoubtedly derived from a northwardly source.

The rocks mentioned are now well known *in place*, their localities and extent, and will be described under their proper heads. The deposits of drift may be seen well developed at West-Point, and along the gravel terrace from the base of the Crow's Nest to three miles below West-Point, and also on the opposite bank of the Hudson one-fourth to one-half of a mile from the river. The boulders and erratic blocks have been mentioned as attaining to a height of about one thousand feet; and there the mass in some places seems to stop suddenly on the northern flanks of the mountains, as if an ancient shore had there existed.*

The valley of Smith's clove contains boulders of conglomerate like that of Skunnemunk mountain; of granite, gneiss, etc. like the Highlands; grits and slates like those of the Hudson valley, and pebbles of the Potsdam sandstone. Boulders of other rocks are found, but those of the vicinity are most numerous.

Dr. W. Horton, who made the geological examination of Orange county, and who has been many years an attentive observer of its geology, speaking of its boulders and erratic blocks, says:

"These are found in the county in the greatest profusion. Most of the surface is thickly dotted by them, and in many places they are so numerous as to prevent cultivation. Under this term, however, it is not intended to comprehend any rocks or stones, except such as have been removed to considerable distances from the place of their formation. Over the whole surface, from the Highlands on the southeast, to the Shawangunk mountain on the northwest, perhaps nine-tenths of the loose stones are greywacke. Many of them are unlike any rock of this description in the county, while others resemble and no doubt were broken up from the layers upon and near which they now lie. The parent rock of the former is to be sought for beyond the bounds of the county; but where, has not fallen under my observation.

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*"Boulders of greywacke similar to that of the Catskill, Shawangunk and Helderberg mountains, are very numerous in many places in the Highlands of New-York. They are found on the summits of the mountains, on their sides, and in the valleys; but they are far more numerous in certain localities than in others. On the northwest slope of the Highlands towards the great valley, and in the upper part of the high lateral, transversal and longitudinal valleys, they are most numerous, and in some instances seem almost to form a kind of horizontal belt encircling the irregularities of the ground, similar in figure to that which would be cut out by a plane passed horizontally, or nearly so, through the hills at the level where they are most abundant." (Mather on Diluvion, West-Point, 1835, pp. 14, 15.)

"The next most common and widely spread boulder, is what is called *Esopus millstone*, and *white flint rock*, or the *millstone grit* of Prof. Eaton. These are found abundantly over all that part of the county between the mountains. They are, almost without exception, completely rounded; none are flat or angular. They are evidently more numerous, and much larger in the northern than in the southern towns. In Montgomery and Crawford, they are often too large to be removed by the efforts and industry of man, even when aided by gunpowder; some may there be seen of five hundred tons weight, and probably much more. As we proceed south, they gradually diminish in size and frequency. How far they extend, I am unable to say, but I have seen them near the New-Jersey line. These boulders are pretty uniform in appearance; their color is white, bluish, or reddish white. It is seldom compact, but generally composed of grains and pebbles from the size of small peas to that of white walnuts, and sometimes much larger; some of the pebbles are smooth and rounded, others are angular; nearly all are united by a siliceous cement. In a few, iron pyrites exist as the cementing substance, or disseminated through the mass; this decomposes when exposed by a fresh fracture, and gives the rock a greenish appearance.

"From what has been stated, I think these masses have been brought into the county from the north by the agency of water. A rock stratum is seen in Blooming-Grove, precisely similar to the boulders just described; but this is shut in by two elevated primitive ridges, and its fragments have had a limited distribution, and can be readily traced to its limit within the county. Boulders of the same millstone grit, and of the same appearance and character, are also found in the valleys of the Neversink and Delaware; but these can also be traced to a stratum in that vicinity, whose fragments have taken a direction not to be mistaken. Another stone which has attracted some attention in the county, is the *labradorite*. Its existence was first noticed by Dr. Heron, of Warwick, several years since. In addition to Warwick, I have seen it the present season in Goshen, Minisink, Walkill, Hamptonburgh and Blooming-Grove. No doubt, if sought for, it might be found in many other places; it is found in pieces weighing from a few pounds up to three or four tons. They are all rounded, and very much worn, having the appearance of travellers from afar. No rock formation of this kind is now known to exist nearer than Essex county. Some pieces of these boulders have been polished, and prove very fine. They usually reflect only the green and blue colors. The best I have seen is in Warwick; also in Walkill, upon the farm of Dr. Shaw; and in Blooming-Grove, upon the farm of Joseph Moffat.

"Many other erratic stones are found, not deserving particular notice; but it should be remarked, that wherever transported fragments of a rock are seen in the county, they are always to the southward of the parent rock. Thus, from the south end of Mount Eve, a chain of blocks can be traced for miles, even into New-Jersey, of a character so peculiar as to render mistake impossible. Another stone found in rolled masses, in the county, is jasper. They are yellow, striped, red and black. Many of them contain cavities, lined with small but beautiful quartz crystals, and coatings of white, blue and yellow calcedony. Some of the jasper boulders are coarse, some fine and compact, some slaty, and some ferruginous.

They have but a limited distribution, being found only at the foot and on the northwestern declivity of Bellevale mountain, in Warwick."*

The region over which Dr. Horton has described the distribution of boulders and erratic blocks, is the great valley between the Highland mountains on the southeast, and the Shawangunk and Kittatinny mountains on the northwest, embracing the Walkill and Long Pond valleys, and parts of the Smith's Clove and Mamakating valleys. The white conglomerate or Esopus millstone rock of the northern part of the county, and many of those of other parts, are undoubtedly from the Shawangunk mountains, which are mostly covered by this rock in place. The *labradorite* is the same as the labrador feldspar which forms mountains in Essex county, described by Prof. Emmons; and no other locality of this rock is known in the United States, where it exists in place. Boulders of it, of considerable size, are scattered over the Hudson valley from its source to New-York, and down the Great valley to Pompton plains in New-Jersey. Boulders of many tons weight are not uncommon in many of the high valleys of the Highlands, where I have often seen it. Near Coxsackie, at an elevation of more than one hundred feet, perhaps two hundred feet above the Hudson, about half a mile below the village, a large block or boulder of this labrador feldspar rock was partly exposed above the surface. Masses weighing, it is supposed, fifty to eighty tons, were blasted from it down to the level of the ground.

The boulders of the Mamakating valley are composed of the rocks of the adjacent mountains, mingled with the northern drift.

The valley of the Schoharie kill contains some boulders of the northern drift, intermingled with those of the rocks of the adjacent mountains. At Schoharie, blocks of opalescent feldspar like that of Essex county, and boulders of a rock composed of augite, coccolite, sphene, plumbago, colophonite and hornblende, occur. Rocks containing the three first of these minerals are common in many places in the Highlands, and the adjoining ranges and hills; but there are peculiarities of appearance in these minerals, and the associated ones in these boulders and blocks, precisely similar to those of rocks *in place* on Lake Champlain at Willsborough, and on Lake George near Rogers' rock. The identity of appearance, and mineral associations, and no other localities than those mentioned being known, give weight to the conclusion that they were derived from those localities. Boulders of granite, gneiss, hornblende-rock containing garnet, pyroxene, scapolite and epidote, are common on the mountains. Novaculite also is common.†

In Saratoga county, the boulders between Schenectady and Ballston-Spa are mostly of the northern primary rocks, intermixed with the Potsdam sandstone and other rocks of the region to the north. Most of them may be referred to their parent localities at no great distance. They are very abundant in many places. About ten miles from Saratoga on the road to Sandy-Hill, boulders abound.

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* New-York Geological Report, 1838, p. 159, 161

† American Journal of Science, Vol. 28, p. 176. J. GEBHARD.

The general characters of the boulders on the west side of the Hudson valley above the Highlands, have been stated. On the east side, there is also a great variety. A smaller number of facts will be adduced on this side; not for want of them, but the reader may think so many superfluous, as the general directions of the transport of the drift of the Hudson valley and Long island are undoubtedly nearly north and south in the former, and northwest and southeast on the latter.

In the vicinity of Poughquaick, in Beekman, "a large share of the boulders is of limestone, mixed with those of quartzose gneiss. Many of the limestone boulders are vesicular, from partial disintegration. After crossing Fishkill creek to the west, there was a change in the boulders and pebbles. The limestone boulders are darker colored, more siliceous, and are evidently from a different stratum.* The quartz boulders are also darker and more abundant, and bear a strong resemblance to those found in the vicinity of the 'primitive argillite.'"†

On the range of hills between Fishkill and Sprout creeks in Lagrange, "the boulders are of those rocks peculiar to the 'primitive argillite'‡ region; consisting principally of milky and brown quartz, with chlorite occasionally adhering."§

Near Barnegat, about three-quarters of a mile north, near the shore of the Hudson, the quaternary yellow and blue clays occupy a small valley. In the lower part of the blue clay, pebbles and boulders of quartz and of grit rock of the Hudson slate series are imbedded, and they seem to have been deposited while the clay was also being deposited; the boulders and pebbles are in many instances smooth and scratched, like those of the blue clay in Ohio and Michigan.

On the mountains between Hurd's corners in Pawlings, and Beekman, which are mostly mica slate and gneiss, Prof. Cassels observed a great number of granite boulders, and also on the east side of the Dover and Croton valley in Pawlings.

In Stanford, south from Mount Stessing, are numerous boulders of granite and gneissoid rocks, like those of that mountain, and also a hard siliceous rock like granular quartz, and which is identical with a similar rock at the south end of the mountain overlying the primary rocks, and underlying the limestone of the valley of Wappinger's creek (the Barnegat limestone, Newburgh limestone, and Calciferous sandstone of the Geological reports). This siliceous rock is believed to be the same as the Potsdam sandstone of Prof. Emmons.

In Columbia county, the sides of the valley extending from Ancram through Copake and Hillsdale, are strewed with an abundance of boulders from the rocks of the neighboring mountains, which are mostly quartz and talcy slate containing veins of quartz; and also with some boulders of limestone, and a dark siliceous highly indurated rock belonging to the Hudson slate, but almost resembling greenstone, and which is found in place in Austerlitz, Canaan,

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* Same as the Barnegat limestone or Calciferous sandstone.

† Chloritic, and containing fragments of the slate.

‡ Talcy, dark colored slate.

§ Prof. Briggs' Field Notes on the New-York Geological Survey. Both the rocks mentioned occur in place on the east side of that valley.

New-Lebanon, Stephentown, Berlin, Petersburgh and Grafton. On the south side of Fog hill in Austerlitz, and on the rise of land north of Green-river village, blocks twenty feet in diameter of this rock were seen. On the western slope, and on some of the most elevated parts of the East mountain, east of the Shaker villages in New-Lebanon, the surface is almost covered in some places with blocks and boulders of limestone, as stated by Prof. Briggs. I have frequently observed, even on the most elevated grounds on this range of mountains, and on the West mountain range, abundance of boulders and blocks of the rocks at no great distance, generally from a northwardly direction.

In the Lebanon valley, between Chatham and New-Lebanon, the quaternary deposits are terraced, and the quaternary clays are covered by a thick deposit of the upper drift, containing boulders of the rocks of the adjacent mountains, with an occasional one of granite, labrador feldspar, etc. from the northern part of the Hudson and Champlain valley. The deposits of drift above the clay beds, are in some instances sixty to one hundred feet in depth.

Boulders on the heads of the Delaware.

Boulders of granite and gneiss, weighing from two hundred to two thousand pounds, were seen in the valley of Betty's brook, a tributary of the Delaware, in the town of Kortright, Delaware county, near the residence of Dr. Marshall, who had long noticed them as being erratic blocks and boulders. They are at an elevation of at least two thousand feet above tide water, and near the head of the valley in which they are situated. They are not very uncommon towards the summits of the valleys where streams flow in opposite directions, in Delaware, Ulster, Greene and Schoharie counties; and as these rocks are so different in their aspect from the common rocks of those counties, they frequently attract attention. Such rocks are found in place only in the country north of the Mohawk valley, and in the Highlands of the Hudson.

Boulders, etc. of other parts of New-York.

Prof. Vanuxem has shown by facts he has related, that the upper drift of the bottom of the Mohawk valley, from Utica down, is from a westerly direction; and also that the drift composed of primary and other rocks forms terraces and irregular hills towards the heads of the north and south valleys which branch to the south from the great valley of the Mohawk, and that the principal accumulations are towards the heads of those valleys,* and that all or nearly all the materials are from rocks in place in a northwardly direction; and that currents have flowed through these valleys from the north, into the tributary valleys of the Susquehannah.† He has also shown that the distribution of the drift in the Black river valley (which in fact is one extension of the Mohawk valley through West-Canada creek to Lake Ontario) is mostly from the north, except the primary boulders from the mountains on the

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* Final Report on the Geology of the Third District of New-York, p. 219.

† Id. p. 235 to 237.

east of that valley, and they are distributed to the south, southwest, west and northwest, around that Primary nucleus.*

Prof. Emmons has shown that boulders of that primary region which comprehends most of the country between the St. Lawrence and Mohawk, the Black river and Lake Champlain, have on the northern and northeastern sides a northern and northeastern distribution.†

Prof. Hall has shown that many of the materials of the drift deposits, which are also collected in great quantities in the north and south valleys of the western part of New-York, are similar to the rocks in a northward direction.‡ These valleys all communicate with the Lakes Erie and Ontario on the north, and with the tributaries of the Susquehannah and Allegany on the south.§

Boulders of Ohio and the Western States.

In Ohio, great numbers of boulders of granitic rocks are scattered over the face of the country; and it may be said with truth, it is believed, that three-fifths of the whole State are covered by a mantle of drift, containing great numbers of primary boulders. I have seen white primary limestone boulders containing tremolite, in Greene county;‖ and opalescent feldspar boulders like that of Essex county (N. Y.), in Franklin county (Ohio),‖ at Sullivant's quarries, where the limestone is stripped of its diluvial covering before quarrying. Nearly all the State, west of the coal formation,¶ abounds with boulders of primitive rocks, intermixed with those of trap, and the rocks of the adjacent country. The primitive and trappean rocks do not exist in place above the surface of the earth, nearer than some distance north of the Great lakes. These "lost rocks," as they are called, in consequence of there being none of the same kind in the region, except in loose masses on the surface, and in the gravel and hardpan beds, are sometimes scattered very sparsely over the surface, and sometimes great numbers are collected in groups, generally upon the edge of a terrace or a swell of ground.

The boulders of Ohio have long attracted attention. Dr. Drake, in his Picture of Cincinnati, has described them as scattered over the whole country high and low, where no causes now in action could place them. One boulder he describes lying in Eaton, Preble county, composed of quartz and mica, and the part lying above ground contained three hundred cubic feet. "The subjacent strata are siliceous limestone."** Mr. Lapham, Judge Tappan and

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* Final Report on the Geology of the Third District of New-York, p. 222.

† Prof. EMMONS. Geological Report of New-York.

‡ Labradorite was rather abundant; and if there be not a similar range in Canada, these must have been derived from the northeast part of New-York. Dr. Bigsby has described this rock in place on Lake Huron.

§ Prof. HALL. Geological Report of New-York for 1840, pp. 336, 337 to 344.

‖ Such rocks are described in place by Dr. Bigsby, in the country on the east side and to the east of Lake Huron. (Vide American Journal of Science, Vol. 8, pp. 66, 70.)

¶ The valleys of the Muskingum and of the Beaver, through the valley of the Sandy and Beaver canal, contain boulders and drift deposits; but the remainder of the coal formation is entirely free of them, and must have been an island or cluster of islands at the epoch of the drift deposits.

** Drake's Picture of Cincinnati, p. 70.

Dr. Hildreth, have described the drift deposits of Ohio.* The geological reports of Ohio contain frequent notices of boulders and drift.† They are generally from the north, but in some instances from other directions. Dr. Locke mentions white granular limestone containing tremolite,‡ at Dayton; and Mr. Whittlesey, masses of grey limestone at Northampton and Boston in Portage county, which resembles in its mineral characters and fossil remains the limestone of Sandusky, and the islands of that region fifty miles west of their present position, which is the nearest known point of their outcrop on the surface of the earth.

Mr. Owen has described the drift as of great extent and thickness in the northern part of Indiana.§ Prof. Shepard has described some of the boulders of the northern part of Illinois, as composed of granite, granitic gneiss and trap, and arranged in belts.‖ Dr. Houghton and his assistants¶ have described those of Michigan. Nearly all the boulders of these western States have their origin in a northwardly direction, and the primary boulders have been transported from beyond the Great lakes on the north.

It has been stated that vast quantities of boulders of primitive rocks are strewed over the great valley of the Missouri and Mississippi, from the Yellowstone almost to the Gulf of Mexico.** Without wishing to contradict this statement, I may be permitted to remark, that although I have traversed the country from the Missouri to near the Gulf of Mexico extensively, both in the States and the Indian country west of them, I have seen scarcely a boulder of the primitive rocks south of the Lower Missouri, except some of no great size and at no great distance south of the primitive range in Missouri. On the upper part of the Missouri, and on the prairies and water-sheds of its northern tributaries, as well as those of the whole Upper Mississippi and of Red river of the North, they are numerous, more abundant, and of greater size as we proceed nearer to the primary granitic tableau, which ranges eastwardly across the St. Peters, Crow river, Mississippi, to Lake Superior, and thence on to the St. Lawrence.

The following notices of boulders have never been published, but are taken from my manuscript report to the Secretary of War, of a geological reconnoisance made from Green bay to the Coteau de Prairie in 1835, in company with Mr. G. W. Featherstonhaugh. As they tend to show the direction of transport in that remote region, and will perhaps aid in solving the problem of the drift, they are inserted. The *m.* and *p.* refer to the manuscript report and page.

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* American Journal of Science, Vol. 13, p. 39; Vol. 14, p. 291; Vol. 23, pp. 300; Vol. 29, pp. 11, 12, 17.

† Geological Report of Ohio for 1838, pp. 16, 17; Id. for 1839, pp. 64, 78, 79, 122, 123, 230, 236.

‡ Bigsby has described such limestone north of the Lakes. (Vide American Journal of Science.)

§ Geological Report of Indiana for 1837, pp. 19, 20.

‖ American Journal of Science, Vol. 24, pp. 141, 142.

¶ Geological Reports of Michigan.

** Catlin. American Journal of Science, Vol. 38, p. 143.

Boulders and Erratic Blocks between Green Bay in Wisconsin, and the Coteau de Prairie.

Localities.	Kind of Boulders, and Remarks.
Garlic island, Lake Winnebago.	Blocks, boulders and pebbles of sienite, hornblende and granite. m. p. 7.
Near Yellow Thunder, Fox river.	Boulders of primitive rocks. m. p. 10.
Six and a quarter, seven and eight miles above the same.	Sand and gravel banks, with boulders of primitive rocks. m. p. 12.
Twenty-nine and a half miles above the same.	Boulders at bottom of steep bank on the river bank. m. p. 13.
Forty-eight miles above the same, on a long point on the south shore of Puckaway or Rush lake.	Boulders were seen on shore and in shoal water. m. p. 14.
Four miles above the marshes of Rush lake.	Boulders and pebbles in the sand and gravel beds. m. p. 15.
Four to six miles from Fort Winnebago, which is at the portage between Fox river and the Wisconsin.	Hills of drift with boulders, pebbles, gravel, and sand of sienite, greenstone, granite, hornblende, gneiss, and limestone of a saccharoidal texture containing a few encrinites. m. p. 16.
Between Fort Winnebago and the quarries of sandstone two miles east of the fort.	Boulders, etc. as above, the limestone containing encrini and terebratulæ. The granite is composed of deep flesh-red feldspar, smoky quartz and black mica; the sienite of similar feldspar, black hornblende and some smoky quartz. m. p. 31.
Wabeshaw's prairie and village on the Mississippi, eight or nine miles above the island bluff (Minechoka). ("Le Montagne qui trempe dans l'eau.")	Sand, gravel, pebbles and boulders of primitive rocks. Under the soil of the prairie, granite, gneiss, sienite, greenstone, amygdaloid, jasper and agate were observed. A block of gneiss was painted red (one of their holy stones). m. p. 37.
Sixteen miles above Wabeshaw's village.	Another boulder painted red, partly in the river. m. p. 40, 41.
Beach of Lake Pepin.	Pebbles of granite, sienite, greenstone, amygdaloid, quartz, jasper, carnelian, calcedony, agate, chert (white, grey and black), hornstone, and siliceous oolite. m. p. 37. Granite was red and grey according to the color of the feldspar. The globules of oolite seemed calcareous, and imbedded in a siliceous matrix. m. p. 40, 41.
Pine Bend hills on the Mississippi, nineteen miles by land below the mouth of the St. Peters, and forty miles by water.	Boulders, blocks, pebbles, gravel, and sand of granite, gneiss, sienite, mica slate, greenstone, amygdaloid, quartz, jasper and agate. Small hills and bowl-shaped hollows like drift of New-England, in some parts of prairies; and many of the hollows exist as lakes, ponds and pondholes. No boulders or stones were seen on the prairies. m. p. 44.
St. Peters, mouth of.	There is a terrace between the limestone rock underlying the prairies and the level of the prairies. This terrace, and the ravines cutting into it every where over a vast region of country on the Mississippi and St. Peters, show a detrital drift down to the level of the subjacent rock. Many of the blocks have sharp edges; boulders and pebbles are rounded and often smooth. This deposit is frequently one hundred feet thick. The pebbles consist of greenstone, granite, jasper, sienite, hornblende, gneiss, mica slate, porphyry, amygdaloid, quartz, calcedony, carnelian, and fine agates. m. p. 45.
Lake beaches near St. Peters.	Covered with shingle and boulders similar to the rocks mentioned above. m. p. 48.
Near Ville Haute on the St. Peters, a high hill, or rather a projecting point of the prairie comes to the bank of the river, one hundred and twenty to one hundred and forty feet high; drift deposits.	Composed of calcareous loam, mixed with pebbles and boulders of the limestone of the adjacent country, and with those of granite, sienitic and hornblende rocks, from the north.
Four miles above the last locality is another similar, with the addition that the limestone is here seen underlying, five or six feet above the level of the river.	Pebbles and boulders similar to those in the last; and in addition, some of greenstone, jasper (red, green and black), hornstone and calcedony. Some of the limestone *pebbles* showed numerous distinct *scratches* upon their surfaces. They were taken by myself from the loam bed in their natural position, and many feet above the highest level of the river, and had doubtless been scratched before they were deposited in this drift formation. m. p. 57. NOTE. I have seen many similar examples in the pebble beds at the junction of the quaternary beds with the slaty and primitive rocks on the coast of Newburgh bay on the Hudson. m. p. 57.
Four or five miles above the mouth of the River Appelle, on the River St. Peters; prairie on right bank.	Prairie hills composed of gravel, pebbles and boulders, sand and loam. Fragments of primitive rocks, as pebbles and boulders most abundant; greenstone, amygdaloid, jasper and limestone common. m. p. 59.
Travers des Sioux, a trading post of the American Fur Company.	Boulders similar to above abundant. Sandstone underlying seen one-third of a mile southeast of the Trading house. Nodules of limonite observed. m. p. 61.
Terre Blanche, a few miles above the Travers des Sioux; sandstone bluff capped with buff limestone.	From top of the bluff, a vast undulating prairie extends afar, presenting thousands of boulders, many of which at a distance resemble herds of cattle or wild animals. The prairie, which is about one hundred feet above the river, seems to have been exposed to the most powerful denuding action, scooping out hollows in the surface, tearing up the limestone which lies scattered about in large blocks, and abrading the surface. The cause does not seem to be a local one, for blocks and boulders of granite, sienite and other primitive rocks are intermixed with those of limestone. m. p. 62.
Mouth of the Terre Bleu river.	Hills of drift deposits similar to those on the St. Peters, overlying the limestone, and that of the sandstone. m. p. 65.
Eleven miles above the same.	Prairie (low); many boulders of primitive and other rocks scattered over its surface. Granite (grey and red), sienite, sandstone, limestone and hornblende. m. p. 66.
Twenty to thirty miles above the same.	Boulders common in the river. m. p. 67.
Thirty to fifty miles above the same.	Boulders abundant in the hills near the river.
Fifty-five miles above the same.	Granite with red feldspar similar to that so often seen in the boulders of the St. Peter's valley, was seen abundantly in place; some of it smooth, as if by attrition, but no scratches.

Localities.	Kinds of Boulders, and Remarks.
Prairie (high), for a few miles above Patterson's rapids.	Boulders of primitive rocks, and buff-colored limestone in the pebble and gravel bed, and scattered over the High prairie. The Low prairie is mostly soil and marshes, with the granitic and hornblendic rocks naked and projecting like islands in many places. m. p. 73.
Grand Portage, on the St. Peters.	The High prairie is connected with the Low almost every where in the valley of the St. Peters by steep couleed slopes, covered with grass; and the mellow blending of the light and shade on these hills, which rise in the distance like a coast, gives a beautiful and peculiar character to the landscape. The High prairie is a mass of boulders, pebbles, gravel, sand and loam, one hundred and twenty to one hundred and fifty feet thick, covering the granitic rocks which show themselves abundantly in the Low prairie like islands. m. p. 75.
Lac qui Parle.	Boulders abundant on the Low prairie, on which the rocks in place do not appear. They were of granite and hornblende.
High prairie near Lac qui Parle.	This lake is surrounded by a high prairie at a distance of from one to five or six miles, and this is elevated about one hundred feet. At an elevation of about three quarters this height, on the slope between the low and high prairie, a line of boulders of primitive rocks is seen stretching in a horizontal belt, as far as the eye can reach. A similar appearance had been noticed before on the prairie hills on the St. Peters, below. Some parts of the prairie were on the same level as this belt, and these parts were strewed with boulders in countless numbers, almost covering the ground; rounded and smoothed so as to have an imperfect polish on many of them, and varying in size from fifty pounds to eight or ten tons. They were of red and grey granitic rock (composed of feldspar and quartz,) sienite, gneissoid hornblende rock, crystalline greenstone, and some buff colored limestone, containing encrini and productæ. They continued to be seen more or less abundantly from Fort Renville at the outlet of Lac qui Parle, to a few miles north of the Pomme de Terre river, where they disappeared entirely, until near Lac Travers. m. p. 79, 80.
Lac Travers, head of the Red river of the North.	Few boulders seen on the High prairie near Lac Travers. Those of buff colored limestone most numerous (m p. 83) The shore of this lake is covered with boulders of primitive rocks. Two large granitic boulders were seen on the High prairie between the Trading house and the Sioux village on the portage between the St. Peters and Lac Travers, painted red by the Indians, and held sacred by them. m. p. 84.
High prairie between the St. Peters and Lac Travers.	These high prairies are thick masses of drift, composed of blocks, boulders, pebbles, gravel, and sand of primary and trappean rocks Small masses of native copper are reported to have been picked up on the gravelly parts of the prairie; and the same is reported of all these prairies, as far as the mouth of the St. Peters. m. p. 87.
Coteau des Prairies.	The sides of this elevated ground, wherever ravines intersected it, showed boulders, pebbles and gravel of primitive rocks, similar to those so often described in the valley of the St Peters. The range of small hills at the foot of the Coteau was similarly constituted; but there these materials were better developed, the boulders and blocks being scattered abundantly over the surface. Epidote and hornblende were abundant in many of the granitic blocks. m. p. 89. One large granitic boulder was seen that had been painted red by the Indians, and was crowned by the skull of an enormous buffalo bull. m. p. 90. The knobs and swells of ground on the summit are formed of the same materials so often described. The whole region seems a vast mantle of drift of primitive, trappean and secondary rocks mingled, of unknown thickness; for no rock is known in place nearer than near the foot of Big Stone lake. m. p 92. In some places on the Coteau, the surface was almost covered by boulders of primitive rocks, mingled with some of buff limestone. Pebbles of jasper, hornstone, limestone, greenstone, agate and calcedony were mixed in gravel beds, which are composed of these and the debris of granite, sienite, gneiss and hornblende rocks. m. p. 94.
Plains between the Coteau and Big Stone lake.	Boulders were observed in some places, but they are confined to detached spots on the surface. The whole of these vast plains are of drift, with soil and loam on the surface, except the patches referred to. m. p. 97.
Big Stone lake.	The shore, in many places, is covered with boulders as thick as the coast on the east end of Long island, or many parts of that of New-England, where a similar deposit is being washed away. The boulders and pebbles are similar to those already described in that region. m p. 97. Granite, sienite, greenstone, hornblende, buff limestone, and calcareous sinter pebbles line the beach near the foot of the lake Some of the buff limestone has circular sections in it, from one tenth to two inches in diameter. This seems an approximation to an oolitic structure, like that of Prairie du Chien and Saratoga. m p. 98.
High prairies between Lac qui Parle and Travers des Sioux.	Few boulders were seen on these high prairies, except where valleys let us down to a lower level, and then the same formation above described was seen. The boulders were mostly granite, sienite, and some of buff limestone. m. p. 107.

Boulders of New-England and the Middle States.

In Connecticut, the general direction of transport of boulders and erratic blocks is nearly from north to south, but there are many exceptions. Red sandstone, precisely like that of Chatham, was observed on the eastern faces and tops of high hills in Marlborough, and the direction seems to have been southeast. Blocks and boulders of granular quartz rock, precisely similar to that of Great hill, three miles east of Middletown, are found in Middletown and for twenty miles to the west.*

* Mather on Diluvion, 1835, pp. 13, 14.

Prof. Hitchcock has shown that the direction of transportation of the boulders in the western part of Massachusetts was from the northwest, and in other parts variable, but generally from a northward direction.*

Dr. Jackson has shown that in Rhode Island, the transport was nearly north and south.† He has also shown, that in Maine, the general course was from the north, and a little west of north.‡

Boulders are very common east of the Blue ridge, as far south as Baltimore and Washington. In grading a street in Baltimore, it was necessary to cut through a pebble bank and solid rock in place. The rock sloped away gradually to the north, and in the direction of the dip. "At the point of the ridge on the south side, is a sudden pitch from the shelving or overhanging of the rock. From this point to the extremity of the section to the south, which is about sixty paces, the bank is filled with rolled pebbles, which, immediately at the pitch of the rock, appear as having been thrown down by cart-loads. From a strict examination of the whole section, it appears as if the pebbles were driven over the surface or north slope of the hill by a powerful current, until they had arrived at this sudden pitch, when they were let fall, or precipitated to the bottom."§ The proofs are positive that the pebbles were brought and deposited by a powerful current from the north.‖ They consist of masses of granite, greenstone, and mica slate. These rocks exist in place only to the north, and from one to three miles distant.‖

In Virginia, Prof. Rodgers has described small boulders, or large pebbles, among the superficial sands.¶

Boulders and drift, like those of the Northern States, are extremely rare in the Middle and Southern States, except as gravel and sand, some of which have been transported, if we may judge from their materials, from far to the north. Pebbles of primary rocks are found in the Mississippi valley as far south as Louisiana, where I observed them, and Dr. Drake has described them at Natchez.**

Dr. Bigsby, in describing the country around Lake Huron, speaking of boulders and erratic blocks, says:

"These fragments are incredibly numerous in Lake Huron, and may be divided into two geological classes, the foreign and the native. The former are more plentiful, and are round and smooth. They are seen every where, but are collected principally in the interior of the coasts and islands, either in confused heaps, or in parallel ridges, and crowning the highest acclivities in great numbers, and the fragments are of various dimensions. They belong almost exclusively to the older orders of rocks, and are therefore†† of a northern origin.

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* Geological Report of Massachusetts, 1841.

† Geological Report of Rhode Island, 1839.

‡ Geological Reports of Maine, 1837, 1838.

§ Hayden's Geological Essays, pp. 47, 48, 49.

‖ Hayden's Geological Essays, ibidem; where the facts observed are detailed at length to prove his conclusions.

¶ Geological Reconnoisance of Virginia, 1836, p. 13.

** Silliman's Journal, Vol. 29.

†† This conclusion, indicated by the word *therefore*, would not be deemed satisfactory without explanation. The rocks in every direction, *except* to the *northward*, are *known*, for many hundreds of miles, to be transition, secondary, and quaternary formations, to the lowest levels to which man has had access. (MATHER.)

Granites, gneiss, mica slate and porphyries prevail, of kinds which I never saw *in situ*, although I have skirted the north shore for two hundred miles, and have traversed the wilderness to the east-northeast for six hundred miles. Mica slate I never met with in a fixed state, excepting a few strata of the black variety at the Falls des Chat on the Ottawa. The other class is small, angular and ragged; they are most frequent on the beaches, whither they are driven by the waves.

"A curious fact is presented by many parts of Lake Huron, and very strikingly in the north channel to St. Mary's. It shows that the debris of the present day is nearly stationary. The containing shores of this channel are of different formations, one being of limestone and the other of greenstone; each shore is lined with its own debris, and without admixture. A few well rolled granites, pudding-stones and an occasional greenstone, do, however, occur among the calcareous matter.

"In the spring, the ice occasionally removes fragments of great size. During winter it surrounds those which are placed in the shallows, and on being broken up in April by the mild weather and casual rise of water,* it carries them to some other shore. Remarkable instances of this are found on the islets near the south end of St. Joseph, where, a few yards from the water and a little above its level, are deposited rolled stones some yards in diameter, with a furrow extending from them to the water, most probably tracing the last steps of the route to their place of rest."†

It may not be improper to state the results of observations made in Europe and other parts of the world, in relation to erratic blocks and boulders.

It was at the foot of the Western Alps, and principally upon the eastern declivities of the Jura mountains which are opposite this great chain, and which are separated by the long and broad valley of the Aar, that the first and most curious observations upon the abundance, size, and position of these erratic blocks were made. In the small valleys between the calcareous crests of the Jura, sixteen hundred feet above the valley, and almost enclosed by high walls of rock, large masses of these erratic rocks were found. They are always on the surface, or at most embraced in the vegetable soil, or loose sand, but never imbedded in any rock. The blocks of each Canton are very similar to each other, but different from those of the other Cantons; it is only in the great valley of the Aar that they are mingled. MM. Escher and De Buch, by examining with care the predominant nature of the rocks of each group of the Alps, by ascending all the valleys, seeking with care the principal bodies from which these blocks had been derived, by means of the scratches and furrows they had left on the rocks over which they had passed, were enabled to ascertain their sources. They found that they must have been derived from the high parts of the mountains, at the heads of the valleys which debouched into the basins, on the sides or bottoms of which they were discovered. They saw that these blocks were similar to the fundamental rock of the mountains:

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* This is very commonly observed on the wind's blowing a few days from the opposite quarter.

† American Journal of Science, Vol. 3, p. 256.

thus those of the valley of the Rhine are similar to the rocks of the Grisons; those of the valley of the lake of Zurich, and of Limmat, are fragments of the rocks of the mountains of Claris; those of the basins of the Aar and of Jura, came from the high mountains of the Canton of Berne. The blocks were observed to be most abundant upon the hills and declivities which are opposite the embouchure of the principal valley; and in the Jura, it is in situations opposite the embouchure of these valleys that the blocks are found at the greatest elevation, some being nearly four thousand feet above the sea. Between the points whence these started, and their present position, the broad deep valley of the Aar, and the lower crests of the Jura mountains intervene, and it seems that they must have passed this space.*

The sandy plains of Holstein, Westphalia, Hanover, Mecklenburg; the shores and plains of Pomerania, Prussia and a part of Poland; and all the sandy plains bordering on the Baltic sea and German ocean, from Ems and the Weser to the Dwina, Neva, and even to St. Petersburgh, are strewed with boulders and erratic blocks. They are not scattered irregularly, but are in groups covering thickly certain spaces which have an oval form, and of which the axis has a direction nearly north and south. They are sometimes very large, and partly or entirely covered by the sand. They consist of sienite, granite and other crystalline rocks, and compact limestone containing orthoceratites and trilobites, which characterize it, not only as transition limestone, but also as belonging to certain beds of this rock in Sweden and Norway. The other rocks indicate the same general direction of transportation, having a perfect similarity in mineral composition and imbedded minerals, to masses of the same kinds of rocks in those countries, and which have not been observed elsewhere in that part of the world. Housman, after a careful examination of the facts, has arrived at the conclusion, that these blocks are separated from their parent beds by the Baltic sea, as those of the Jura are by the valley of the Aar.†

Crossing from Holstein to Sweden through Scania, the train of these blocks is not lost sight of for an instant. The soil is covered in many places in the Swedish provinces by the masses of the wrecks of mountains, as they are called by most travellers, who have been struck by their appearance. In Smoland, Scania, Sudermanie, and Uplande, the blocks are accumulated in masses forming small hills of a peculiar form, long and narrow, more elevated at one extremity than the other, ranging from north-northeast to south-southwest, and composed of sand and granitic gravel, containing enormous blocks of granite and sienite. These rocks continually increase in numbers from the countries south of the Baltic, to those on the north towards their parent sources; but they do not appear to be larger than those at a great distance.†

Russia and Finland present immense accumulations of erratic blocks. In Finland they are so numerous and large, that the roads are made crooked to avoid them.

In England they are common, and in the counties of Norfolk, Suffolk, Cheshire, the east

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* Brongniart, Terrains de l'écorce du globe. Paris, 1829, p. 76. † Id. pp. 77, 80.

coast of Yorkshire, and on the hills in Derbyshire, they are abundant. Some of them seem to have come from distant countries, and probably from Scandinavia. They are generally rounded; others come from the mountains of England; and although the rocks are much more tender than the preceding, their edges and angles are preserved.*

The investigations in England, within a few years, have shown that the causes that have spread the drift deposits have been influenced by the relative levels and topographical features of the country, so far as never to cross the high ranges of hills and mountains, except at their lowest points, or by sweeping around their ends.† The same fact has been observed in the Alps and country around, each kind of rock following its respective valley.‡

In Iceland, an island supposed to be entirely volcanic, blocks of granite, containing many cubic yards, are said to have been found on the most elevated points.§

In South America, large blocks of granite have been found on the mountains of Potosi; and it is not known in place nearer than Tucuman, a distance of four hundred leagues.§

In India, enormous blocks of granite are cited as being piled on each other in the district of Hyderbad, in 17° north latitude.§

Prof. Struder states, that in the hill country at the foot of the Himalayah mountains in India, erratic boulders occur.‖

Darwin and others have observed boulders and erratic blocks in great numbers in South America, between Cape Horn and the forty-first degree of south latitude.¶

De la Beche and Prof. Hovey describe diluvial detritus as abundant in Jamaica, and especially on the plain around Kingston, in the West Indies, and that it appears to have been drifted from the north.‖

The facts above narrated constitute one train of evidence in regard to the *direction* in which the drift deposits have been transported in the eastern part of New-York in particular, and in the United States and other parts of the world generally. Another train of evidence bearing on this subject also, is recognized in the smoothed and scratched surfaces of rocks in place, on mountains, in valleys, and over extensive plains; and this also affords the same kind of presumptive evidence of the direction and *mode* of transport as the other, but in a still more striking manner.

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* Sedgwick, Annals of Philosophy, April and July, 1825; and Buckland, Rel. Diluvianæ, pp. 202, 203. For a more particular account of those of England, vide De la Beche's Manual, p. 160; Conybeare and Phillips' Geology of England and Wales; Phillip's Treatise on Geology, &c.

† Phillips, Treatise on Geology, 1838, p. 209; and Encyclopædia Britannica, seventh edition.

‡ Phillips, Treatise on Geology, p. 207.

§ Brongniart. Terrains de l'écorce du globe. Paris, 1829, p. 83.

‖ Hitchcock's Elementary Geology, p. 186.

¶ Lyell's Elements of Geology. Philadelphia, 1839, pp. 86 to 89.

Smoothed and Scratched Surfaces of Rocks.

In many parts of Europe and America, the rocks have been found beneath the superficial materials of the earth, with smoothed surfaces, as if ground off by attrition. They are sometimes smooth and polished; sometimes scratched, grooved and furrowed, on the smooth surfaces. The cause that has produced the scratches and smooth surfaces seems to have acted in a nearly uniform direction in each locality, conforming to the great topographical features of the country to a certain extent, but with numerous local variations, which are, it is believed, capable of a satisfactory explanation. Various theories have been offered to account for these appearances, which are observed on elevated grounds and high mountains, as well as on plains and in valleys. The principal are, first, the attrition caused by powerful currents of water moving gravel, pebbles, boulders and blocks along the surface; secondly, floating ice having these materials imbedded in their mass, grinding along the bottom, where the water was not deep enough to float them clear; and thirdly, glaciers with rocks, etc. imbedded, and sliding to a lower level, as we now see in elevated districts, above and near the region of perpetual snow.

A great number of examples of these smooth and scratched surfaces have been observed in the First Geological District; and for conciseness and facility of reference, those detailed will be put in a tabular form. Great numbers that were observed were not registered, for they were so common that the localities would fill a volume, and would be useless repetition; but enough have been registered to show the general direction of the action of the forces causing them, and the numerous local deflections, the resultant apparently of the resolution of two or more forces acting obliquely to each other.

The grooves, scratches and smooth surfaces are most frequently seen on level or slightly inclined surfaces of the rock, but they have in many instances been observed where the surface of the rock was inclined 45°, 50°, and even nearly perpendicular. In these cases, the mass causing the scratches seemed to have been deflected from its course after meeting these obstructions; grinding and rounding off the irregular parts of the rock in place, and sliding off again into deeper water.

The scratches are found on all the consolidated rocks in place that have been protected by a covering of loam or clay, and that do not disintegrate below the surface when covered with such materials. The harder rocks (with the exception of the slate and talcose rocks of the Hudson and Taghkanic groups) show the scratches most distinctly, as the trap, granitic, gneissoid and conglomerate rocks, and the hard blue limestones and grey grits.

The examples observed in the First district of New-York will first be adduced; then others in other portions of our country, that may eventually aid in the determination of the causes of the drift. Where the direction of the scratches is not noted in the localities in the First district, it was in most cases from fifteen to twenty degrees west of north and east of south, in the eastern part of the Champlain and Hudson valley.

Examples of scratched and furrowed rocks in the First Geological District of New-York, and near its boundary in Massachusetts and Connecticut.

No. of examples.	Name of observer.	Kind of rock smoothed and scratched.	County in which the locality was observed.	Direction of the scratches.	Reference to works in which the observations are registered.	LOCALITIES.	REMARKS.
1	Mather.....	Coarsely crystalline trap	Richmond...	Not noted ..	m* vol. i, p. 192	At the "Granite quarries," as they have been called, one or one and a half miles south of Shooter's island, and two to four miles south-southwest of Tompkinsville.	Smoothed, but rarely scratched.
Several. 5	De Kay.....	Gneiss	New-York ..	NNW & SSE	Am. Jour. Sc. vol. 16, p. 357	Several places in the city of New-York.	
Several. 5	Mather.....	Gneiss, micaceous	do ..	N 25° W ...	m. i, p. 114.	A few rods southeast of the intersection of the Third avenue and Fftieth-street. The rock ranges N. 25° E. Dips at a high angle to the N. 70° W.	The strata for some distance to the north and south of this place dip to the north and northwest from 30° to 80°; but near Seventy-seventh-street, the rock resumes its dip to the east and southeast.
2	Gale	Granite.....	do ..	N 48° W ...	N. Y. Geol. Rep. for 1839 p. 198.	.....	Most of the localities are on the top and northwest sides of the hills.
39	do	Gneiss and mica slate	do ..	N 45° W ...	do	On the middle parts of the island, between the city and Harlem valley, in the line of the Eighth avenue from Sixtieth to One-hundred-and-fifth-street.	On top, all are N. 45° W. The few on the east sides of the hills are from N. 25° to N. 35° W. Those on the west side are N. 35° W.
7	do	do	do ..	N 35° W ...	do		
5	do	do	do ..	N 25° W to N 35° W	do		
7	do	do	do ..	N 35° W to N 45° W	do		
1	Briggs.....	Hornblendic gneiss	Westchester.	Not noted, various directions	m. ii, p. 64.	One mile north of Sodom in North-Salem.	
Many, say 8	do	Gneiss and hornblendic gneiss	do ..	Not noted ...	m. ii, p. 71.	Road from Greenwich, Connecticut, to New-York, in Rye, New-Rochelle, Westfarms and Westchester.	Very striking and obvious.
Many, say 8	Cassels	Gneiss	do ..	N 15° W ...	m. vii, p. 23.	Almost everywhere, and particularly on the highest hills where the rocks are freshly uncovered by taking off the earth.	
8	Mather.....	Talcose slate	do ..	N 20° W to N 30° W	m. vi, p. 72.	Gallows hill on the west side and top, four to four and a half miles north of Peekskill.	On the road very distinct.
1	Cassels	Gneiss	do ..	W of N and E of S	m. vii, p. 41.	On the post-road, two miles southeast of Verplanck's point. Deeply furrowed.	Line of bearing N. 20° E.
1	do	Hornblendic rock	do ..	Not noted ..	m. vii, p. 42.	Near the south dock of Peekskill, on the east side of the road.	Deeply and coarsely furrowed.
1	Briggs.....	Mica slate ..	Putnam.....	N 10° W ...	m. ii, p. 226.	Patterson, half a mile from the line of Connecticut, on the road from Danbury to Poughkeepsie.	Strike of rocks N.E. and S.W. Dip to S.E.
1	do	do	do	N 15° W ...	m. ii, p. 226.	Patterson, three quarters of a mile southeast of Wing's corners, same road.	
1	do	do	do	N 15° W ...	m. ii, p. 227.	Patterson, one and a half miles southeast of Wing's corners, same road.	
Several, say 2	Mather.....	Gneiss	Litchfield co. Conn.	N 20° to 25° W	m. iii, p. 23.	Both east and west of the village of Norfolk, at the heads of the two valleys between which this village stands. Norfolk stands in an elevated shallow valley on the mountain between two transverse valleys at their heads, leading west and southeast.	
1	Hitchcock ..	Mica slate ..	do	Few degs. W of N & E of S	Hitchcock's Geol. Report Mass.	Canaan mountain in Connecticut.	

* m. refers to the Manuscript Diary of the Geological Survey of the First District of New-York.

No. of examples.	Name of observer.	Kind of rock smoothed and scratched.	County in which the locality was observed.	Direction of the scratches.	Reference to works in which the observations are registered.	LOCALITIES.	REMARKS.
1	Briggs*	Slate	Dutchess ...	NNW	m. ii, p. 241.	Nine miles from Poughkeepsie on the road to Patterson.	
Many. 10	do	do	do	NNW	m. ii, p. 242.	On the road from Patterson to Poughkeepsie, very common on slate rocks.	Strike of rocks N. and S. or N.N.E. or S.S.W.
1	do	do	do	NW and SE	m. ii, p. 51.	Amenia, between Mr. Wheeler's and Van Benschotten's.	
1	do	do	do	N 15° E	m. ii, p. 256.	Near a school-house, nine miles from Poughkeepsie on the road to Amenia, in the valley of Wappinger's creek.	
1	do	do	do	NW to SE ..	m. ii, p. 45.	In Northeast on Winchell's mountain, on farm of Maj. Denton.	Very distinct.
Many, say 20	Mather	Bluish hard grit rock	do	Not noted, generally about N 15° to 30° W	.....	Between Fishkill and Rhinebeck, but particularly well characterized near the ninety-fifth mile stone, two or three miles south of Rhinebeck.	
1	do	Slate	do	N 30° W ...	m. iii, p. 467.	Two and a half miles west of Pineplains on the western declivity of the mountain.	Well characterized.
1	Hitchcock ..	Gneiss	Litchfield co. Conn.	N 10° to 15° W	Hitchcock's Geol. Report Mass. p. 388.	On Mount Tom (highest mountain) near Litchfield.	
1	Merrick* ...	Not noted ..	Dutchess ...	Not noted ...	m. v, p. 89.	In southeast part of Pineplains.	
1	Mather	Slate	do	do	m.	Half a mile to one mile north of Pineplains, on the east side of the road. Surface of rock highly inclined.	
1	Cassels *...	Mica slate ..	do	N 35° W ...	m. iv, p. 120.	On the mountain west of Hurd's corners in Pawling, on the road to Beekman Centre.	
1	do	do ..	do	Northwardly not noted	m. iv, p. 129.	On the top of the mountain about three miles west of Ameniaville, just on the western brow.	
1	Mather	Hard grey grit	do	NE	m. iii, p. 473.	Three quarters of a mile west of Lower Redhook. Rock smooth, except the scratches.	
1	do	do	do	Not noted ...	m. iii, p. 473.	Quarter of a mile west of the above, on a small ridge that emerges from the sandy loam.	
1	do	do	do	N 10° E N 20° E double set	m. iii, p. 485.	Two miles south of Lower Redhook landing, forty or fifty feet above the Hudson, and ten rods from the shore, where a clay bank had been washed off and left it exposed.	
1	do	do	do	Not noted ...	m. iii, p. 487.	On the road side between Rhinebeck and the landing, west of the ridge where the rock paves the road, and west of the creek.	
Several. 8	do	do	do	do	m. iii, p. 487.	On the Rhinebeck and Pineplains turnpike.	
1	do	do	do	do	m. iii, p. 487.	Two and three quarter miles from Lower Redhook, on the road to Long pond, in the northeast part of Rhinebeck.	
1	Cassels	Slate	do	do	m. iv, p. 174.	Hyde-Park, half a mile east of the post-road, on the road to Clinton that branches from the post-road half a mile north of De Graff's tavern. The slate has been shifted by slight faults since the scratches were made.	
1	do	do	do	do	m. iv, p. 173.	A little out of the village of Hyde-Park, three quarters of a mile east of the river.	
1	Merrick	Talcy slate ..	do	do	m. v, p. 100.	Summit of the highly elevated lands or mountain called Chesnut ridge, ranging from Winchell's mountain on the north to Fishkill mountains on the south.	
1	do	Hard grit ...	do	do	m. v, p. 112.	A little south of Rhinebeck village, near the post-road.	
Several, say 8	do	do	do	do	m. v, p. 112.	Between Rhinebeck and Redhook.	
Several, say 8	do	do	do	do	m. v, p. 112.	Frequently seen for five or six miles east of Upper Redhook.	
Many, say 12	do	do	do	do	m. v, p. 134.	Southeast part of Redhook, and the northeast part of Rhinebeck.	
Many, say 10	do	Hard grit and slate	do	do	m. v, p. 134.	Northeast of Redhook, and northwest part of Milan.	

* Professors Briggs, Gale, Merrick, Cassels, and Dr. W. Horton were principal assistants on the Geological Survey of the First District of New-York.

No. of examples.	Name of observer.	Kind of rock smoothed and scratched.	County in which the locality was observed.	Direction of the scratches.	Reference to works in which the observations are registered.	LOCALITIES.	REMARKS.
Many, say 20	Merrick	Argillaceous and siliceous slate and grit and mica slate	Dutchess....	Not noted ...	m. v, p. 141.	On the road from Redhook by Rock city to Amenia.	
Many, say 20	do	Grit and slate	do	do	m. v, p. 151.	Abundant in Washington, Stanford and Clinton.	
Many, say 10	do	Gneiss	do	do	m. v, p. 163.	Between Stormville in Fishkill, and Milltown in Putnam county.	
1	Lawrence ...	Talcy slate ..	Columbia ...	N 45° W ...	m. ii, p. 27.	Mountain top, east of Shaker village in New-Lebanon.	
1	do	do	do	N 45° W } N 45° E }	m. ii, p. 27.	Six miles north of the preceding locality.	Double set.
1	Briggs	Slate	do	NW & SE ..	m. ii, p.	Eight miles from the Shaker village on the north side of Fogg hill, in sight of Flint's tavern.	
1	do	do	do	Not noted ..	m. ii, p.	Near the top of Fogg hill in Austerlitz, a few rods south of the second house from the preceding locality.	
1	do	do	do	N 10° W ...	m. ii, p. 307.	Near Brown's hotel, Chatham Four Corners, Ghent, on the railroad track of the Hudson and West-Stockbridge railroad.	
Many, say 8	do	Slate and talcy slate	do	N 20° W to N 30° W	m. ii, p. 339.	New-Lebanon, on the mountain east of the brick yard, Shaker village.	
1	do	Limestone ..	do	N – W	m. ii, p. 345.	Near the alum rock, north of Lebanon springs, on the west side of the mountain.	
Many, say 10	do	Slate and talcy slate	do ...	NNE and S SW?	m. ii, p. 350.	On the mountain north of New-Lebanon springs.	
1	do	Slate	do	Not noted ..	m. ii, p. 382.	New-Lebanon, "near Moffit's."	
1	do	do	do	do ..	m. ii, p. 385.	New-Lebanon, "near Grant's."	
1	do	do	do	N 18° W ...	m. ii, p. 288.	Twelve miles from Hudson, on the road from the southwest part of Canaan to Hudson.	
1	Mather	do	do	N 55° W ...	m. iii, p. 84.	On the side of the Hartford and Hudson turnpike, near the line between New-York and Massachusetts, at an angle of the transverse valley of the mountain, two hundred feet above the bottom of the valley, and probably fifteen hundred to two thousand feet above the Hudson.	
2	do	do	do	N 20° W } N 50° E }	m. iii, p. 85.	On the same turnpike, eleven miles from Hudson; one about one hundred and fifty yards east, and the other two hundred yards west, of the turnpike gate.	
1	do	do	do	Not noted ...	m. iii, p. 151.	Two miles southwest of Kinderhook, on the east side of a by-road, near the road from K. H. to Hudson.	
1	do	Talcy slate ..	do	do	m. iii, p. 225.	On the Columbia turnpike, three miles east of Hillsdale, on the west side of the mountain.	
1	do	do	do	do	m. iii, p. 225.	On the summit of the mountain, on the turnpike from Hillsdale to Egremont and Stockbridge.	
1	do	do	do	do	m. iii, p. 225.	On the summit of the same mountain, two or three miles north of the preceding, on a cross road from Little-York in Egremont, leading west over the mountain to M. T. Palmer's, in Hillsdale.	
1	do	Slate	do	N 30° W ...	m. iii, p. 279.	In the top of the gorge of the mountain, two and a half miles northwest of Hillsdale, in the road on the farm of Andrew Shorts.	
1	Cassels	Not noted, but on slate	do	Not noted ...	m. iii, p. 279.	Two miles west of the preceding, on Joseph Goodsel's farm.	
1	do	Slate	do	N 35° W ...	m. iv, p. 102.	On the top of the hill, four and a half miles from Johnstown, on the road to Hudson.	
Many, say 20	Merrick	Talcose and argillaceous slate rocks filled with veins of quartz	do	N 23° W ...	m. v, p. 62.	Austerlitz. All the mountain north and northeast of Green river for three or four miles, seems to have been ground off smooth by diluvial action. Grooves and scratches very distinct and uniform in direction.	

No. of examples.	Name of observer.	Kind of rock smoothed and scratched.	County in which the locality was observed.	Direction of the scratches.	Reference to works in which the observations are registered.	LOCALITIES.	REMARKS.
Many, say 8	Merrick	Hard grit and slates	Columbia ...	Not noted ...	m. v, p. 134.	On the road from Redhook to Miller's in Taghkanic, thence to Churchtown and Claverack.	
1	Hitchcock ..	Argillaceous slate	do	N 15° W ...	Hitchcock's Geology of Mass. p. 388.	Copake, west side of Taconic mountain.	
50	do ..	Talcose slate	Columbia and Rensselaer	NW and SE	do	Western slope of Taconic mountain, near top, on the west side, the whole breadth of Massachusetts near the New-York line.	Very distinct, and extending down the slope some hundreds of feet.
1	Mather	Slate	Washington.	Not noted ...	m. x, p.	One and a half miles south of Salem, on the northern declivity of a high hill.	
1	do	do	do ..	N 75° E	do	Near the church, on the summit of the high hill between Easton and Cambridge.	
1	do	do	do ..	N 60° W ...	do	On very elevated ground in the summit of a high transverse valley, about one mile north from Easton.	
1	do	do	do ..	Not noted ...	do	One and a half miles from Easton, on the road to Buskirk's bridge.	
1	do	Calciferous sandstone	do ..	do	do	Near the falls of Wood creek, one and a half miles northwest of Fort Ann.	
1	do	Hornblende rock	do ..	N 55° E	do	In a small transverse valley, half a mile east of Fort Ann.	
1	do	Gneiss	do ..	Not noted ...	do	On the road from Fort Ann to Comstock's landing.	
1	do	do	do ..	do	do	On the road from Comstock's landing to Whitehall.	
2	do	Blue limestone	do ..	N 10° to 15 E°	do	One or two miles south of Negro point in Putnam, on the shore of a point of Lake Champlain. The rocks are much scratched, and overlaid by beds of *scratched limestone pebbles* intermixed with clay, and this deposit is overlaid by the quaternary clay beds.	
1	do	do	do ..	do	do	On the same point as above, and shows not only slight scratches, but depressions to the southwest of hard points of the rock as if gouged out, and showing the action of water flowing a long time in one direction.	
1	do	do	do ..	do	do	On Mr. Goulard's farm at the lime kiln in the north part of Putnam, within a few rods of the granitic rocks in place, and covered by the clays of the quaternary, elevated about one hundred and fifty feet above Lake Champlain, and three-quarters of a mile west of the shore.	
1	do	Imperfect chloritic slate a metamorphic rock	do ..	Not noted ...	do	On a highly inclined surface of the rock, on the east side of the valley, about one and a half miles northeast of Cambridge.	Pointed out to me by Rev. Mr. Newton.
Many, say 10	Mather and Cassels	Gneiss and granite	Rockland ...	do	m. vii, p. 115.	On the top of the mountain between Grassy point on the Hudson, and McFarlan's iron works in Smith's clove a little west of the turnpike gate, and on several ridges farther west.	
Several, say 20	Mather and Cassels	Trap rocks ..	do ..	do	m. vii, p. 127.	On the road leading south from Haverstraw over the mountains of trap, and in returning between the High Torn and Little Torn. All these gorges are waterworn and abraded, where uncovered of the soil that has protected the rock from decomposition or slow disintegration.	
Several, say 8	Mather	Slate and grey grits	Orange	do	Mather on diluvion, 1835, p.	On the bank of the Hudson, between Cornwall and Newburgh, overlaid by scratched pebbles of slate and limestone, intermixed with boulders of grey grit and primitive rocks, and this latter deposit overlaid by the clay and sand beds of the quaternary.	
Several, say 8	do	Gneiss and granite	do	do	.....	At West-Point, where the rocks were freshly uncovered, many places were observed where the rocks had been ground off, and rubbed smooth. Where they are exposed to the weather, they are rough from disintegration in a slight degree.	
1	Thompson ..	Grey grits * C D	do	N and S	Am. Jour. Sc. vol. 23, p. 245	Twelve or fourteen miles west of Newburgh.	

* These grits belong to the Old Red sandstone, or Catskill Division of rocks, and are designated by the letters C. D.

No. of examples.	Name of observer.	Kind of rock smoothed and scratched.	County in which the locality was observed.	Direction of the scratches.	Reference to works in which the observations are registered.	LOCALITIES.	REMARKS.
Great No. say 100	Mather	Grey grit of the Hudson slate	Ulster	N and S to N 20° W	m. ix, p. 12.	Over all the west and north sides of the hills and mountains between Dashville on the Walkill and Esopus on the Hudson, five hundred to one thousand feet above the Hudson. Scratched boulders were also seen.	
1	do	Black slaty limestone	do	Not noted ...	m. ix, p. 59.	In the valley of the outlet of a pond, half a mile south-east of Clark's white lead factory.	
Several, say 8	do	do	do	do	m. ix, p. 47.	Between Kingston and Rosendale.	
Many, say 40	do	Slate and grits of the Catskill division	do	N 20° E to N 30° E	m. ix, p. 54.	Between Kingston and the flag-stone quarries west on the mountain, and thence by Woodstock, and down the valley of the Saghkill to Kingston.	
1	Eights	Slate, H D* .	do	.....	Zodiac, i, p. 112	On greywacke in a quarry in the village of Ulster. Rocks worn smooth, as if by rapid currents, with *pot-holes.*	
1	Thompson ..	Grey grit rock C D	Greene	N and S	A J † 23, p. 247	At Coxsackie, in a well.	
1	Mather	do C D	do	N 40° E and east	m. ix, p. 170.	Five miles from Durham on the road to Catskill.	Double set.
1	do	do C D	do	N 70° W and west	do	Two miles east of Durham.	do
Many, say 10	do	Grey grit C D	do	Not noted, but probably NE and SW	m. ix, p. 177.	Head of Mitchill's valley, on the road from Prink-street to Windham, one thousand two hundred to two thousand feet above tide water.	
Many, say 30	do	Grey grit and red grit C D	do	Not noted ...	m. x, p.	Near the Mountain House on the Catskill mountain, and within two miles on the road to Catskill.	
1	do	Grey grit C D	do	N 70° W S 70° W	do	At the fork of the roads a quarter of a mile from the Mountain House, at a gap of the mountain.	do
1	do	do C D	do	N 45° E N 15° E	do	On the road from the Mountain House, half a mile towards Catskill.	do
1	do	do C D	do	N 35° E N 5° E	do	On the same road, one and a half miles towards Catskill.	do
1	do	do C D	do	N 17° E	do	On the same road, a mile and three quarters towards Catskill.	
1	do	do C D	do	N 30° E N 10° E	do	On the first terrace west of the valley of the Kiskatamine creek, a quarter of a mile west of the church at the base of the mountain.	do
1	do	do C D	do	N 15° E	do	On the rocks by the first house east of Kiskatamine creek, where a large surface is ground off smooth, and more or less scratched.	
1	do	do C D	do	N 45° E	.....	On the top of the valley over the mountain, between West-Durham meeting-house and the gap towards Gilboa, at least fifteen hundred feet above the Hudson.	
Several, say 4	do	do C D	do	N 70° to 80° E N 40° to 60° E	m. ix, p. 160.	On the road from Prink-street in Durham towards Catskill, one or two miles.	do
Several, say 8	do	do C D	do	Not noted ...	m. ix, p. 162.	Between Pleasant valley and Oak-hill.	
Several, say 10	do	do C D	do	do	.....	Between Potter's hollow and the summit of the mountain, on the turnpike from Catskill to Gilboa. Several boulders were also seen on this road with "diluvial scratches" on them, and many others in the valley of Fox creek, between Preston-Hollow village and Weeden's mineral spring, in the edge of Albany county.	
Several, say 8	do	Red and grey grits C D	Sullivan	N 10° to 15° E	m. ix, p. 223.	Between Monticello and Bridgeville. Common over all the ridges.	
1	do	Grey grit C D	do	Not noted ...	m. ix, p.	On the Newburgh and Ithaca turnpike, a quarter of a mile east of the Delaware river.	
Several, say 8	do	Red and grey grit C D	do	N 10° E	m. ix, p. 224.	Between Monticello and Forrestburgh. All these elevated lands, where the rock is recently uncovered of soil, show the worn and scratched surfaces.	

* H. D. is for the Hudson slate division.

† A. J. refers to the American Journal of Science.

No. of examples.	Name of observer.	Kind of rock smoothed and scratched.	County in which the locality was observed.	Direction of the scratches.	Reference to works in which the observations are registered.	LOCALITIES.	REMARKS.
50	Thompson ..	Puddingstone and grey sandstone C D	Sullivan	N to N 65° W	A J, 23, p.243.	Various parts of the elevated lands of Sullivan county.	
2	do ..	Old red sandstone C D	do	N and S turned E by an obstruction, then NE after passing it	A J, 23, p.247.	On the north sides of the hills.	
11	do ..	Grits of C D.	do	N 78° to 80° E	do	On the eastern declivity of the mountains west of the Mamakating valley.	Furrows deep and distinct.
1	do ..	Grey sandstone C D	do	N 65° W and S 65° E	do	South of the preceding, and the grooves are directed towards a low gap in the Shawangunk mountains.	
1	do ..	.....	do	Not stated, furrows intersected	do	Locality not stated.	Double set.
1	Mather	Grey grit....	Schoharie ...	Not noted ...	m. x, p.	From a half to a quarter of a mile north of Summit corners, at least sixteen hundred feet above tide water, probably over two thousand feet.	
Several, say 5	do	Grey grit and slaty grit	do	do	do	Between Summit corners and Jefferson academy, probably twelve hundred to sixteen hundred feet above tide water.	
1	do	Flagstone grit	Albany	Not noted, but NE and SW if memory serves	do	At the flag-stone quarries in Coeymans, on the summit of the ridge, probably eight hundred to one thousand feet above tide.	
				Other parts of New-York.			
Great number.	Emmons	All rocks....	Clinton, Warren, &c. 2d Geol. Dist. N. Y.	N and S	Geol. Rep. N. York, 1839, p. 234.	Every where in the northeast part of the State of New-York. Second Geological District.	
Several.	Vanuxem ...	Trenton limestone	Montgomery.	Nearly E and W, some 8° S of west	Final Report Geol. 3d Dist. N. Y. p. 245.	Near Amsterdam. Various quarries and localities. Conform to the valley.	
1	do ..	Conglomerate	Oneida	Near N and S	do	Mason's quarry between Utica and New-Hartford. Conforms to the smaller or Sauquoit valley.	
1	do ..	do	do	do	do	Near the Oriskany, to the north of Stebbins creek, and not far from the Chenango canal.	
	do ..	Encrinal rock of the Clinton group	do	do	do	On the west of the Oriskany north of Hamilton College. Corresponds with the Oriskany valley.	
	do ..	Calciferous sandstone	Montgomery.	.....	do	On the north side of the Nose, to the east of Spraker's house. Conform to the valley of the Mohawk.	
	Hall.....	Limestone ..	Wayne, Monroe, &c. 4th Geol. Dist.	NNE & SSW	Geol. Rep, N. York, 1838, pp. 307, 308.	All the country between the Genesee and Niagara rivers.	
1	Thomas	do ..	Niagara	N 25° E	Am. Jour. Sc. 17, p. 408.	Lockport, New-York. On the rock at the deep cut of the canal.	
1	do	Sandstone ..	Monroe	N 80° E	do	Brockport, east side of Genesee river.	
1	do	Limestone ..	do	Not noted ...	do	On the east side of Genesee river.	
Many.	Dewey.....	do ..	do	NE and SW	Am. Jour. Sc. 37, p. 240.	At Rochester, and many places in the vicinity in the Genesee valley. Rocks generally worn smooth, and scratched.	
				In Pennsylvania, Ohio and Western States and Territories.			
Several.	Mather	Limestone...	State of Ohio	Not noted, but northwardly and southwardly if memory serves me	Personal observation	On the smoothed surface of the limestone where the blocks, boulders, pebbles, etc. of the drift deposit have been removed, at Sullivant's quarries in Franklinton, three miles west of Columbus, Ohio.	

No. of examples.	Name of observer.	Kind of rock smoothed and scratched.	State in which the locality was observed.	Direction of the scratches.	Reference to works in which the observations are registered.	LOCALITIES.	REMARKS.
1	Locke	Limestone ..	State of Ohio	N 19° to 33° W, generally N 31° W	Geol. Report of Ohio, 1838, p. 231.	Light's quarry, seven miles north of Dayton, Ohio, on the elevated grounds of the Miami valley, where stripped of loam, bearing large oak trees. Force acted from northward to southward.	
—	—	—	do	NW and SE	Hitchcock's Geol. p. 21.		
—	Mather	Limestone ..	do	Not particularly noted, but from a N to S course	Personal observation.	Common on the limestones from the Scioto to the Miami valleys where freshly exposed by removal of the superincumbent drift deposit. This is often very thick.	
—	—	—	Pennsylvania	Not stated ..	Hitchcock's Geol. p. 191	Common on the mountains of Pennsylvania.	
—	Thomas	Old red sandstone	.....	do ..	A J, 17, p.408.	On the Montrose and Milford turnpike, south of the great bend of the Susquehannah, fifteen hundred feet above tide level.	
1	Mather	Limestone ..	Missouri	Scratches scarcely perceptible	Personal observation.	On the bank of the Mississippi a broad level surface of rock is exposed to the current of the river at high water, which sweeps sand and pebbles along, and has smoothed and polished the rock over many hundred yards in length and one hundred or two hundred in breadth, about one mile below Jefferson barracks, and eleven below St. Louis. The ice is also frequently forced over the same smooth plateau of limestone.	This example is the result of alluvial action, but it illustrates the mode by which rocks may have been smoothed.
1	do	Granite	Iowa Territory	Smoothed rocks	do	Enormous masses of granite protruding through the alluvial and quaternary deposits of the valley of the St. Peters, at the foot of Big Stone lake, are worn smooth, and all their angles rounded off. They are *in place*, and seem to have been worn thus at the time the water flowed through this valley at a higher level than at present. High prairie terraces of the drift skirt the valley, perhaps one hundred feet high, and the valley is perhaps a mile broad. These masses of rock are supposed to have given the name to the lake. The boulders of these prairies have already been alluded to.	
	do	Hard siliceous compact sandstone, like the Potsdam sandstone	do	do	MS. Report to Sec. of War, 1835; and Mr. Featherstonhaugh's Report also to Sec. of War, 1835, p. 146.	These were observed on elevated ground, on the left bank of the St. Peter's river, near the mouth of the Rivière aux Liards, about two hundred miles above the mouth of the St. Peter's, near the southern border of the primary rocks that range thence by Lake Superior and north of the lakes, to the St. Lawrence at the Thousand islands. The rock was worn smooth, with numerous pot-holes like those seen at water falls. The holes were smooth as glass, as were the surfaces of the rocks generally. Some of the holes were two feet deep and more, and a foot in diameter. Some of them were cleaned out, and pebbles found in them.	
	do	Limestone ..	do	do	Personal observation.	Rocks were often seen smoothed near where they passed under the drift deposits in the valley of the St. Peter's; but as no artificial causes have there uncovered the rocks, the exposed portions, if they had been scratched, no longer showed them, though they did show the *smoothing* action of water and of the materials transported by it.	
—	—	.....	Michigan ...	NW and SE	Hitchcock's Geol. p. 191.		
			Illinois	do	do		

In New-England.

1	Mather	Coarse grey sandstone of the New red sandstone	Connecticut .	Not noted, but northwardly and southwardly	Personal observation in 1833.	On the side of the New-Haven and Hartford turnpike, one and a half or two miles northeast of Meriden.
Many, say 10	do	Trap rock ..	do ..	Not noted, but NE'ly and SW'ly if memory serves	do	On West mountain, on the Hartford and Albany turnpike on the east side of the mountain, southeast of Wadsworth's tower.

No. of examples.	Name of observer.	Kind of rock smoothed and scratched.	State in which the locality was observed.	Direction of the scratches.	Reference to works in which the observations are registered.	LOCALITIES.	REMARKS.
1	Mather	Mica slate ..	Connecticut .	Not noted, E'ly & W'ly if memory serves me	Personal observation in 1833.	At the gap of the mountain in Bolton, on the Hartford and Providence turnpike.	
2	Hitchcock ..	— ..	do ..	N 18° W ...	Geol. of Mass. p. 395.	Canaan mountain and Mount Tom in Litchfield.	
Several.	do ..	Gneiss	Massachusetts	.....	Hitchcock's Geol. Mass.	Top of Wachuset mountain, three thousand feet above tide.	
Many.	Silliman	.....	do	NE to SW ..	A J, 27, p. 342.	Lowell, half a mile from the river, near the place where the railroad enters the town.	
Many.	—	Conglomerate	do	Uniform towards the ocean, course not specified	Bost. Jour. Sc. 1, p. 91.	In Roxbury and Dorchester.	
1	Mather	do	do	S'ly up an inclined surf. of smooth rock 4° or 5°	Personal obs. in 1832.	In Newton, two and a half miles E.S.E. of the Baptist Seminary, half a mile S.W. of a small pond.	
Great number.	Hitchcock ..	Talcose slates and primary rocks	do	NW and SE	Hitchcock's Geol. Report 1841, p. 394.	Throughout the west part of Massachusetts, even the highest mountains. Some exceptions.	
do	do ..	Prim., trap & other rocks	do	N and S or slightly W of N and E of S	do	Throughout the valley of the Connecticut river. Some exceptions.	In the north part of the valley, N. 8° to 13° W. and in the south part N. 8° to 13° E.
do	do ..	Slate, conglomerate, sienite, etc.	do	N 15° W ...	do	Throughout the eastern part of the State. Some exceptions.	
do	do ..	.....	do	NNW & SSE	do	In the northern part of Essex county.	
1	do ..	Gneiss	do	N 18° W ...	do	In Royalston.	
1	do ..	do	do	N 38° W ...	do	In Petersham.	
1	do ..	do	do	N and S	do	In Princeton. Supposed to be deflected by the Wachusett mountain.	
Many.	do ..	Trap rock ...	do	N and S or in some cases N 5° or 10° E	do	About Mount Holyoke and some of the valleys. Deflection caused by the course of the valley.	
1	do ..	Talcose slate.	do	N 78° W ...	do	In Florida. Hoosac mountain, two thousand four hundred feet high.	
Several.	do ..	do ..	do	N 5° to 10° W	do	In north part of Rowe and Windsor, southwest part of Saddle mountain, on Bald mountain, and in the tunnel in the east part of Saddle mountain.	Causes of deflection apparent in forms of mountains and valleys.
Several.	do ..	Mica slate ..	do	N 18° W ...	do	Mount Washington and Mount Everett.*	
Many.	.....	All hard rocks	Rhode-Island	N and S nearly	.....	Various parts of the State.	
1	—	Granite	New-Hampshire	—	A J, 14, p. 20.	Grafton, in top of valley between the Connecticut and Merrimack rivers, one thousand feet.	
Many, 30	Jenkins	Granitic gneiss	do	N and S	Hitchcock's Geol. Mass. p 389.	On the top of Mount Monadnock, at a height of three thousand two hundred fifty feet above the ocean, over many acres.	
Many.	do	do	do	N 10° W ...	do	On the west and northwest sides of the same mountain.	
1	Hubbard	Granite	do	E and W ...	A J, 34, p. 107.	On the west side of a ridge on an inclined surface near the stage road in Rumney towards Plymouth.	
Many places.	Ball	Gneiss	do	N 60° W ...	A J, 22, p. 166.	On a mountain in Hebron. Common on the mountain rocks in that vicinity.	
	Jackson	Slate	Maine	N 20° W ...	2d Geol. Rep. Maine, p. 50.	Belfast. Grooves across contorted slate.	Vide also Dr. Jackson's letter to Prof. Silliman: American Journal of Science, Vol. 34, p. 72.
	do	do	do	N 5° W	do p. 65.	Scarboro'.	
	do	Talcose slate.	do	NW and SE	1st do p. 57.	In Belmont.	
	do	Slate	do	N 15° W ...	do p. 28.	In Charleston.	
	do	Gneiss	do	N and S	2d do p. 91.	Near the corner of Winthrop on the road to Redfield.	
	do	Mica slate ..	do	N 5° E	do p. 91.	In Winthrop.	
	do	Granite	do	N 10° W ...	do p. 95.	Hallowell granite quarries.	
	do	—	do	N and S	do p. 96.	Richmond on the road to Portland.	

* It is unnecessary to enumerate all the examples observed by Prof. Hitchcock in Mass. Those above stated show the *general directions* and the *principal exceptions*. For numerous examples, the reader is referred to Prof. Hitchcock's Geological Report of Mass. 1841, p 386 to 388.

The Hon. W. Thompson, speaking of scratched rocks in Sullivan county (N. Y.), says:

"I have examined this part of the State with considerable care, and have found that in more than fifty places where I have seen the solid strata, the grooves and furrows are from one inch to one quarter of an inch deep, and from a quarter of an inch to three or four inches wide; and in many places they run due north, and in every direction from north to twenty-five degrees south of east. I have found them also in the bottoms of cellars, of excavations made in digging wells, and where the earth has been removed by making roads, and in many instances where I have uncovered the solid rock for the purpose of observing the effects of diluvial action.

"I have never been able to find any grooves or furrows on the west side of the hills and ridges in the county. It very rarely happens that any traces can be found on the red argillaceous sandstone; it is not sufficiently solid to sustain the force of heavy bodies moving in contact with it, although in some instances the grooves appear from fifteen to twenty feet, and then the strata are rough and broken; but the traces are mostly on the solid puddingstone, and the common grey sandstone.* In those cases where the old red sandstone appears, if the slope or side of the hill faces the north, I have seen three or four instances in which the furrows run in that direction for half a mile; and on meeting a ridge of rocks in the low grounds, the furrows turned due east, and after passing the obstruction, again turned northeast or east. Not a mile from the same place, on descending from the high ground, the furrows run east, tallying with the face of the hill.

"On the high lands west of Shongham, and where there could be no obstruction for seventy or eighty miles, I examined ten or twelve different places in which the furrows were deep and distinct, and found them to run from ten to twelve degrees north of east, and they continued down the mountain in the same direction, a considerable distance. At no great distance to the south, the furrows tended twenty-five degrees south of east, leading to a low opening in Shongham mountains."†

Mr. Appleton, speaking of the smoothed and grooved surfaces of rocks which have not been exposed to the action of atmospheric agents, remarks: "I have noticed this in every part of New-England, and of so marked and diversified a character as to leave no doubt in my own mind of its universality, but it may not be every where so obvious. Our hills show their hard primitive faces wherever a new turnpike requires the removal of the natural soil to any extent, and this hardness of surface withstands for a long time the action of the weather. It is not, however, to be inferred that these indications are confined to primitive rocks; they are nowhere more striking or more beautiful than on the puddingstones in this vicinity" (Boston).‡

Boulders and pebbles with scratched surfaces have very often been seen while engaged in the geological survey of New-York, and several examples have been mentioned. The best observations recorded on this subject are by Mr. Peter Dobson.§ He says, "I have dug up a great number of boulders of red sandstone of the conglomerate kind, in erecting a cotton manufactory; and it was not uncommon to find them worn smooth on the underside, as if done

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* These rocks both belong to the Catskill or Old Red Sandstone division.

† American Journal of Science, Vol. 23, pp. 243, 247. ‡ Id. Vol. 11, p. 102. § Id. Vol. 10, p. 217.

by their having been dragged over rocks and gravelly earth in one steady position. On examination, they exhibit scratches and furrows on the abraded part; and if among the minerals composing the rock, there happened to be pebbles of feldspar or quartz, which was not uncommon, they usually appeared less worn than the rest of the stone, and preserved the more tender parts of the mass in a ridge extending some inches. When several of these pebbles happened to be in one block, the preserved ridges were on the same side of the pebbles, so that it is easy to determine which part of the mass moved forward in the act of wearing. I have caused blocks with the above appearances, and weighing fifteen tons, to be split up; and there were many others dug from the same place and vicinity, weighing from ten to fifty hundred weight, some of which were two hundred feet above the stream of water in the vicinity. These boulders are found not only on the surface, but many feet below, in a hard compound of clay, sand and gravel. One block of more than thirty hundred weight, marked and worn as above described, was dug out of a well at a depth of twenty-four feet. Boulders with these marks upon them I have seen not only in this town (Vernon, Conn.), but in Manchester and Ellington (Conn.), and in Wilbraham (Mass.).

"I think we cannot account for these appearances, unless we call in the aid of ice along with water; and that they have been worn, by being suspended and carried in masses of ice over rocks and earth under water."*

Smoothed, scratched and furrowed rocks have been observed in Europe, where observations on this subject were first made; but they are not common there, as in the northern parts of the United States in North America.

Scratches and smoothed rocks have been observed by MM. Brongniart and Berzelius in Sweden and Norway, and particularly in the vicinity of Hogdale;† and "Monsieur Sefstroom," says the distinguished Berzelius, "has found that the northeast part of the mountains of Sweden are, throughout, rounded and worn from the base to the summit, so as to resemble at a distance sacks of wool piled upon each other. The southwest side of these mountains present almost fresh fractures of the rocks, with their angles rounded little or none."‡

In Scotland, Sir James Hall noticed them many years ago on greenstone a d other rocks, with a direction northwest and southeast, in the vicinity of Edinburgh. He says, "Where a mass of rock has been followed under ground to where its surface has been protected by a covering of clay, it is found to resemble a wet road, along which a number of heavy and irregular bodies have been recently dragged; indicating that every block that passed, had left its trace behind." They agree generally in parallelism, with a few deviations, and agree in direction to the ridges and valleys and large features of the district. Fifteen examples are given on a map of the Costorphine hills. In the immediate neighborhood, the direction of the current was from the west, conforming to the hills of the estuary of the Forth; but near Sterling, and in other places in that region, it was from the northwest.§

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* American Journal of Science, Vol. 10, p. 217.

† Brongniart. Terrains de l'écorce du globe. Paris, 1829, p. 82.

‡ Hitchcock's Elementary Geology, p. 191.

§ Transactions of the Royal Society of Edinburgh, Vol. 7; and Buckland, Rel. Diluvianæ, p. 202 to 205.

Lieut. Col. Imrie observed scratches and surfaces smoothed by attrition, on the trap rocks on the Campsey hills, and in the glens and valleys, and on an elevated plain. Boulders of trap, covered with scratches, were also observed, with their angles turned to the northwest, and showing, by this means and the scratches, the direction of the current.*

Prof. L. D. Gale, speaking of grooves, furrows and scratches of the Island of New-York, says:

"Diluvial grooves and scratches have been found in every section of the island, from Sixteenth-street on the south, to 200th-street on the north, (or to the southern termination of the limestone;) and from the banks of the Hudson on the west, to Harlem river on the east. The furrows generally are most distinct where the rock has been recently uncovered, and least so where it has long been exposed to the action of the elements. They have been found on the highest rocks, and at the lowest tide-water marks, being a difference of more than one hundred feet perpendicular height. The furrows are always most strongly marked on the northwestern slopes of the hills, and least so on the southeastern. In many instances they are very distinct on the western and northwestern slopes, extending to the highest point of the rock; but no traces are to be seen on the eastern and southeastern slopes, although both slopes are equally exposed.

"*Direction of the furrows.* Observations of the diluvial furrows were made in between sixty and seventy different places on the island. Taking together the whole series of observations, the general course of the current was from northwest to southeast, or north forty-five degrees west, but varied in the extremes from north twenty-five degrees west to north forty-eight degrees west, making a difference of twenty-three degrees. Of the whole series of observations, thirty-nine were north forty-five degrees west, twelve varied from north forty-five degrees west (seven being north thirty-five degrees west), two were north forty-eight degrees west, and a few scattering ones varying from north thirty-five degrees west to north forty-five degrees west.

"*Abundance of the furrows.* The furrows occur most abundantly in the middle portions of the island, between the city and the Harlem and Manhattanville valley, somewhat less in the western, and least of all in the eastern.

"*Direction of the furrows in particular neighborhoods.* Half of all the places where the furrows were noticed were in the middle portion of the island, in the line of the Eighth avenue from Sixtieth-street to 105th-street, where without exception the direction is north forty-five degrees west. About one fourth of all are on the west side, and vary but little from north thirty-five degrees west; and about one-eighth on the eastern side, where the direction varies from north twenty-five degrees west to north thirty-five degrees west. In connection with this subject, I have examined the surface of the greenstone on the neighboring shores of New-Jersey, and find their grooves and scratches abundant, and their general direc-

* Transactions of the Wernerian Society, p. 35; and BUCKLAND, Rel. Diluvianæ, p. 202.

tion is north forty-five degrees west. Hence it appears, that the diluvial current which once swept over this island from northwest to southeast, on reaching the western shore, was deflected southward, as by the action of some force at a right or some other angle to its course; and that the same current, before it reached the middle of the island, again assumed a southeasterly direction, but was again diverted southerly on approaching the eastern shore. That some portion of the current was diverted southerly on reaching the western shore of the island, is evident, not only from the diluvial furrows, but from the boulders of anthophyllite found in large numbers in the lower part of the Eighth avenue near Fifteenth-street, a distance of two miles in a south-southwest direction from the only locality whence they could have proceeded. Again, the white limestone of Kingsbridge has been distributed along the eastern shore of the island, in a direction almost due south of the only locality in the vicinity where it is found in place; whereas had they been carried in the general direction of the current, they would have been deposited eastward in Westchester county, as before stated.

"*Magnitude of the furrows.* The size of the furrows varies in the same and different localities. Sometimes they are the finest scratches, not more than a line in diameter horizontally, and of the smallest appreciable depth; from this they increase to grooves four inches deep and eighteen inches in horizontal diameter. In a few cases, they are furrows, or rather troughs, more than two feet wide and six or eight inches deep. A case of the latter kind occurs on Eighth avenue, between Seventy-ninth and Eighty-first-streets; and one of the former on the west side of the island, on the very banks of the Hudson, five hundred yards north of Mr. John H. Howland's country seat (near Ninety-seventh-street).

"*Convenient places for examining the diluvial furrows.* The nearest places to the city for examining the furrows are at the junction of Twenty-second-street and First avenue, south of the Alms-house yard; and again about half a mile northward at Kip's bay, at the junction of First avenue and Thirty-fifth-street. Both of these localities will soon be destroyed by grading the streets. Some of the most interesting localities have been made known by cutting through Eighth avenue, from Bloomingdale road, at or near Sixtieth-street, to Harlem and Manhattanville valley at 105th-street; these localities are on both sides of the avenue, and very conspicuous. Another, equally interesting in many respects, is on the banks of the Hudson, west of the Bloomingdale road, about six miles from the city, and about six hundred yards northwest of Burnham's hotel. The interest excited by this locality arises from the fact, that the furrows ascend from beneath the lowest tide water, up to an elevation of seventy feet in three hundred or four hundred feet distance."*

It will be seen by referring to the tables, that the scratches on the east side of the Hudson and Champlain valley, on the mountain tops, are mostly directed northwest and southeast, as their general direction; those of the west side of that valley, from northeast and east, to southwest and west, as common directions; those of the high range of land along the divide of the waters of the St. Lawrence valley, of the Great lakes, and the waters of the Dela-

* Geological Report of New-York, 1839, pp. 197, 199.

ware, Susquehannah and Ohio, are northwardly, generally west of north; those at lower levels, but considerably elevated, are intermediate between the directions last mentioned, and the general trend of the valleys in which they are located; while those in the lower parts of main valleys, conform more nearly to the general directions of those valleys.

The local variations from these as general directions, are nearly all susceptible of satisfactory explanation, when we take into view the topography of the country, and the deflections and eddies that would be produced in currents, by meeting such a contour of bottom and shores, as the present form of the surface would produce if it were covered with water.

It is unnecessary perhaps to go into a detail of examples to show this result; but there are two striking exceptions, as they would appear to be, to one unacquainted with the topographical features of the country. The *most striking* is that of the elevated lands along the eastern part of New-York and western part of Massachusetts, where, by referring to the tables, the reader will perceive that the scratches are mostly from northwest to southeast. The phenomena that have been related indicate, that at some former time, the country, to the tops of the high mountains, was covered with water, and that strong currents flowed through the Mohawk and the Champlain and Hudson valleys. The great depth and breadth of the Mohawk valley is sufficient, it is believed, to have given direction and force to that volume of water flowing through it, to be felt and made manifest by the abrasion of masses of rock, to as great a distance as where the facts were observed by Prof. Hitchcock and myself. I have studied with some care the topographical features of Massachusetts as well as New-York, and believe that all the apparent anomalies of direction of the scratches may be reconciled upon similar principles, taking an enlarged view of the topographical features of the country, and considering the general directions that would be given to currents flowing over and among them, the local eddies and deflections caused by the irregularities of the ground, and another cause that will be mentioned in its proper place, when discussing the direction of currents.

The other principal exception is on the northwest side of the great valley, between the Highland mountains on the southeast, and the Catskill mountains and their prolongation on the northwest. The tables show many scratches from the east and east-northeast, and some even from the southeast; but they nearly all conform to the rule that is almost universally found to hold true, viz. *that the scratches high on the sides of the valleys are laterally oblique to the direction of the main valley;* and this valley seems to have been originally the *main* valley, or the prolongation of the Champlain and Hudson valley to the southwest.

Summary of the Facts on the Drift Deposits.

1. The surface of the earth throughout the First district of New-York, and in fact throughout the whole northern portion of the United States, included in the great valleys of the St. Lawrence, the Upper Mississippi, and north of the Ohio river, and also through the northern parts of

Europe, is more or less covered with a mantle of drift deposits, composed of boulders, blocks, pebbles, gravel, sand and clay, variously mingled together, or stratified in separate masses.*

2. These materials, over most of the northern parts of the United States, and of the northern parts of Europe, are similar to rocks in place to the northward of their present positions.* Very many of them have been traced to their parent sources, by trains of evidence that are so strongly marked, in some instances, as to leave no doubt of the distance and direction of their transportation.
3. These depositions preceded the alluvial, and were deposited at a later period than the tertiary.
4. Heavy boulders and blocks of many hundred tons weight, as well as smaller ones and pebbles, are frequently *intermingled with*, or deposited *on*, beds of *clay* and *sand*.
5. Broad and deep valleys, lakes, and arms of the sea, and hills and ranges of mountains of moderate height, intervene between the parent sources and the present resting places of much of this detritus.
6. The boulders and blocks are sometimes scattered nearly uniformly over great extents of country; in other parts they are collected in nests or groups, great numbers being found on small areas, while in other parts around they are rare.
7. These groups of boulders are not unfrequently seen on plains and in valleys, but they are more common on the sides of hills and mountains, or on the edges of the terraces.
8. Great numbers of boulders and blocks are sometimes seen arranged in a nearly horizontal belt, following all the sinuosities of the ground; but more numerous in the valleys along these belts than on the projecting points, as if they had lodged in and around *bays*, more abundantly than on the *headlands*.
9. Gravel hills (containing boulders and blocks) somewhat peculiar in form and general aspect, characterize the gravel deposits of drift in many parts of the northern district of the United States, and particularly in New-England and New-York.†
10. Boulders and pebbles are often found in the situation in which they have been placed by natural causes, with their smoothed surfaces *scratched* in straight lines; and in some instances where there were hard portions on some parts of the worn surfaces, they seem to have protected a portion of the softer material, leaving it in a ridge behind each of them, and all parallel, as if the boulder had been dragged along in a *fixed position* over other hard bodies, which had worn away the softer parts, except those protected by the harder points.

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* The drift detritus has been examined from the Atlantic coast in Nova-Scotia, New-Brunswick, Maine and the Eastern States, to the Coteau de Prairie between the head of the Mississippi and the Upper Missouri, and found to present numerous evidences of transport from the north and northwest, with the exception of the high primary region between Lake Champlain and the Black river, and the St. Lawrence and Mohawk, from which boulders seem to have been dispersed north, south, east and west, to great distances, and particularly to the south. In Europe, the direction of transportation seems to have been from the northeast and north-northeast, except around the Alps, from which boulders and blocks have been dispersed in every direction through the main valleys. The southern portions of the United States and Europe show few evidences of the transportation of heavy blocks and boulders. Few have been seen south of the Ohio or of the Lower Missouri; but gravel and small pebbles of northern rocks, with their characteristic minerals, have been observed as far south as Mississippi and Louisiana, where I have often seen them.

† These hills are *distinct* in character from those at the embouchures of *valleys*, and which correspond to the bars at the mouths of rivers. Those referred to, are found *in* valleys, and on great extents of country of a nearly uniform *general* level.

11. The scratches on rocks *in place*, the transportation of boulders and blocks, and the scratching of some of the latter, were all contemporaneous.
12. Scratches, grooves, furrows, and smoothed surfaces are frequently found on the rocks in place, when uncovered of the soil that has protected them from disintegration, over most parts of the northern portion of the United States, in the regions in which boulders and erratic blocks are found.
13. These scratched, grooved and smoothed surfaces are found on the *high mountain tops* (but more abundant in the valleys that traverse them), on the sides of hills and mountains, in valleys, and in *broad level tracts* of country (like Ohio and Western New-York).
14. *Directions of scratches.* By considering the numerous observations that have been made on this subject, I find that they conform in their directions to those in which *currents would flow*, if the country were mostly covered by water. In some parts, they correspond in direction to the main water-sheds of the country. In others they do not; but in most instances where they do not conform, the cause may generally be seen by studying the topographical features of the country, and taking into consideration some phenomena of currents that will be mentioned in their proper place in a subsequent part of this discussion.

Pot-holes.

These are found on elevated ground, and present all the appearances of those formed at waterfalls by the gyration of pebbles (harder than the rock) at the present time; and in situations where neither the highest floods, nor any causes acting as they do at the present time, could produce them. I have seen but two examples: One near the mouth of the Rivière aux Liards, elevated from fifty to one hundred feet above the level of the St. Peter's river, in Iowa territory, and mentioned in the table of scratched and smoothed rocks; the other at the Little falls of the Mohawk, and described by Prof. Vanuxem* and by others.

Another example has been given by Prof. Emmons, in Antwerp, St. Lawrence county, N. Y. "It is at least one hundred feet above the Oswegatchie, three-fourths of a mile distant, with an intervening hill, higher by some fifty feet than this remarkable hole. This ledge of rocks skirts a valley on the west which is about one hundred rods wide, and its direction is about north and south. This hole is from twenty-four to thirty feet deep, and from twelve to fourteen feet in diameter, bearing the usual marks on the interior of water-worn surfaces. Upon the summit of the intervening high ground and the river, we find the polished rocks; in one place a mass of the Potsdam sandstone still adhering to the primary, seven or eight feet in diameter, of an oval form, and about two feet thick, is all that remains of the stratum at this place, and grooved in the usual manner, with the scratches in a north and south direction."†

Another example of *pot-holes* is described in Grafton, New-Hampshire, on the crown of a high valley, on the divide between the waters of the Connecticut and Merrimack rivers, at an

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* Natural History of New-York: Geological Report of the Third District, 1842, p. 209.

† Geological Report of New-York, 1840, pp. 351, 352.

elevation of about one thousand feet above them.* Three of these holes were observed within a few feet of each other; two circular, and about three and two feet in diameter, and several feet deep; the other, oblong, and of greater diameter. The rock is smooth, and seems to have been worn away to a depth of fifteen or twenty feet, over a breadth of forty or fifty feet. Among other proofs of this fact, another worn cavity is mentioned, eight or ten feet higher than the others, and a little back of the middle one. This cavity is very perfect, and is plainly to be seen to the depth of six or seven feet, about three feet in diameter at top, apparently perfectly round, and like other cavities known to be formed by the action of gravel and water. Its diameter increases very regularly and gradually as it grows deeper; and that which makes it still more certain that it is the effect of gravel and water, is, that about three or four feet from the top, the rock on one side of the cavity projects on one side into the hole three or four inches, exactly as those rocks do that are *known* to be worn by gravel and water, where a part of the rock is harder than the rest. This is clearly the case here, as that part of the rock is of a more compact texture and of a different color.*

The occurrence of pot-holes at high levels, far above the reach of currents of water flowing as they do at present, is conclusive evidence that the level, the quantity, and the velocity of water, have, at some former period, been different from what they are at present, at their localities; and their occurrence with smoothed rocks, and near extensive depositions of drift, render it highly probable, though not absolutely certain, that they were formed at the epoch of the drift deposits.

THEORIES OF ERRATIC BLOCKS, BOULDERS, SCRATCHES, &c.

Many theories have been advanced to account for the transported blocks, boulders and gravel; the scratches, smoothed surfaces, and the various phenomena connected with the drift deposits. Some of them, in their prominent features, and brought into as concise a form as practicable, are subjoined. They were framed so as to account in the most plausible manner for the facts then known.

1. That of Deluc, who supposed these blocks had been cast into the air by the force that had elevated the mountains, and that they had fallen at a greater or less distance; according to the power of this force and its direction.†

2. That of MM. De Buch, Escher, &c., who supposed that an immense deluge swept the boulders and blocks along, and forced them up the acclivities of the mountains by means of the impulse they had received.†

3. Others have thought that the blocks, pebbles, etc. were the wrecks of a mantle of rocks of similar kinds, which originally covered the surface, and of which these are the only remains.†

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* American Journal of Science, Vol. 9, pp. 30, 31.

† BRONGNIART. Terrains de l'écorce du globe. Paris, 1829, pp. 76, 77.

4. Dolomieu supposed that the summits of the Alps and Jura mountains might have been once connected by a regular inclined surface of ground, down which the masses may have rolled; and perhaps during the same convulsion that rolled the masses down, the ground has been broken, or sunk to assume its present form.*

5. Venturi sought to explain their transportation from the summits of the Alps to the valleys of the Po, by bringing in the aid of ice, either of glaciers, or of floating ice.*

6. Some have supposed the Jura mountains to have been on a level with the base of the Alps, and that these mountains were elevated, carrying with them the boulders and blocks that had been previously tumbled to the base of the Alps.*

7. M. De Buch, by developing the first theory, and applying it to particular phenomena, thought that the dispersion of the erratic blocks was a consequence of the elevation of the Alps, posterior to the deposition of the tertiary formations.†

8. The phenomena of the drift have very generally been attributed to the deluge of Noah.

9. M. Agassiz, the distinguished naturalist, is now attracting much attention by his attempts to explain the transport of boulders and blocks, and the scratched surfaces, by the effects produced by *glaciers* in the Alps and other mountain regions, and applying them to the phenomena observed in England, Scotland, &c.

10. Another theory, maintained by many distinguished geologists, supposes the phenomena of the drift period to be due solely to ancient alluvial action, produced with no greater intensity than the causes acting at the present time.

11. The phenomena of the drift deposits are attributed to the action of the retiring waters of the ocean, as mountain chains were suddenly upheaved.

12. Another theory attributes the effects to the elevation of the bed of the Arctic ocean, which caused a flow of water from the polar region, transporting ice loaded with rocks and gravel southwardly over the American and Eastern continent.

13. Another, proposed I believe by Prof. Esmark‡, attributes the phenomena of drift to transportation by icebergs; and the scratches, to these, with rocks frozen in and grinding upon the bottom, where there was not a sufficient depth of water to float them clear.

14. Others, to explain the phenomena in the United States, refer the cause to the drainage of a vast inland sea through the valleys of the St. Lawrence, Hudson, Susquehannah, Ohio, &c.; § and to the sweeping of a debacle from the north,‖ floating ice with its freight of rocks and earth.¶

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* Brongniart. Terrains de l'écorce du globe. Paris, p829, p. 77.

† The preceding theories were mostly framed before many investigations had been made, except in the region of the Alps and Central Europe.

‡ Vide American Journal of Science, Vol. 31, p. 362.

§ Maclure. American Journal of Science, Vol. 6, p. 98.
Maclure. Journal of the Academy of Natural Sciences, Vol. 1, p. 261.
Tappan. American Journal of Science, Vol. 13, pp. 291, 297.
Hall. New-York Geological Report, 1840, pp. 431, 444.
Ackerly on the Geology of the Hudson. Mitchill's edition of Cuvier's Theory of the Earth. Et multis aliis.

‖ Hildreth, Am. Jour. of Science, Vol. 13, p. 39. Hayden, Geol. Essays. Thompson, Am. Jour. of Science, Vol 23.

¶ Hitchcock. Redfield, American Journal of Seience, Vol. 32, p. 351.

15. Others have attributed the effects to a change in the axis of rotation of the earth;* and others, still, to the collision of a comet with the earth.†

It will be observed that the theories adduced are nearly all calculated to explain facts that are more or less local, and many of them offer a sufficient and apparently a philosophical explanation of the region to which they apply; but the facts *now* known, show that the cause was not confined in its action, as was at one time supposed, to the region of the Alps, then to the northern part of the Eastern Continent, and afterwards to the northern part of the Northern Hemisphere; but from the knowledge now possessed, it is believed to have acted with equal force, and over an equal extent of the Southern Hemisphere. We must then seek for some *cause* which shall have affected the EARTH, and which is capable of explaining in a philosophical manner the various effects produced over such vast areas of the earth's surface.

It may be here premised, that the nature of the case is such, that the evidence cannot be *direct*, but is necessarily *presumptive*, and confined to reasoning from *effects* to their *causes*, and inferences from *facts considered* as well as established, and from the *recognized* laws of nature. If these, or any of them, should not prove true, the superstructure built upon an unstable foundation must necessarily fall, and the theory that will be proposed, like those that have preceded it, must add one more to the numerous theories that have been framed to account for the various phenomena of geology, and found, as knowledge progressed, to be insufficient.

The following propositions are necessarily preliminary to the farther consideration of the subject:

1. The earth is in the state of a cooling body.
2. Cooling bodies diminish in volume.
3. Bodies revolving on axes, or in orbits, by a diminution in their diameters or their orbits, increase in their velocities of rotation.
4. An increase in the velocity of rotation implies an increase in the centrifugal force.
5. An increase of centrifugal force tends to cause a greater oblateness in the spheroidal form of a revolving spheroid.
6. The earth is an oblate speroid, of such a form as is due to a fluid body revolving with its present velocity.

The above are admitted philosophical truths and laws of nature.

If it can now be shown that the *earth has diminished in volume*, it would demonstrate that there has been a flow of water from the polar regions towards the equator, to restore the equilibrium that would necessarily follow on such a body, of which a part of the surface is fluid, revolving with an increased velocity; or reciprocally, if it can be shown that there has been

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* APPLETON. American Journal of Science, Vol. 11, pp. 103, 104.
† Halley's Essay on the Causes of the Flood, in 1694.

a flow of water from the polar regions, that cannot be explained by any known dynamical law, then such a contraction is highly probable.*

A long train of argument might be brought forward on each of these subjects, both tending to the same result. I shall treat them very concisely.

(A.) *Refrigeration and contraction of the earth.*

(*a.*) The investigations of various philosophers have demonstrated beyond all doubt that the *earth becomes more and more warm, as we penetrate farther below its surface*, (after having passed the surface of equable temperature, down to which the temperature is variable from the influence of the seasons.)

(*b.*) The *form* of the *earth* is precisely that which would be *due to a fluid body revolving with the present velocity of the earth;* and there is no other cause to which we can properly ascribe its *former*, and probably its *present* interior fluidity, but caloric.

(*c.*) The varied mathematical investigations of Fourier, Cordier, Poisson and Svanberg, upon caloric, the refrigeration of heated bodies, and upon the temperature of the earth and of space,† notwithstanding the various conclusions, all tend to show that the *earth is in a cooling state*, and *radiates into space more caloric than it receives*, although it has long ago reached what may be called an asymptotic condition.

These may be considered as affording evidence *almost* demonstrative that the earth is a cooling body, and consequently diminishing in volume; consequently increasing in its velocity of rotation, and in the centrifugal force; and, consequently, in the tendency to a flow of water from the polar to the equatorial regions.

(B.) *Currents from the polar regions.*

The train of argument on this subject may also be reduced to a few words:

(*a.*) It has been shown that the general directions of boulders and erratics are southwardly from their sources;‡ and the scratches, in most instances, are also similar in direction, in the northern hemisphere.

(*b.*) That *currents* AIDED in the transportation of most of the erratics, is evident, by most of them having been deposited within the areas of the principal valleys of drainage, or through which currents would necessarily flow, if the waters of the ocean were at a relative elevation

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* If it can be shown, in addition, that there ARE *dynamical laws* that necessarily cause such currents as we have under consideration, that have acted through all time when there was a fluid for them to act upon, and that they would be heightened in effect by the refrigeration of the globe, and that we can trace distinctly the effects of such causes, the evidence may be considered demonstrative. The discussion will necessarily be somewhat discursive, instead of being confined to distinct propositions.

† Memoirs de l'Institute. DE LA BECHE, Geol. Manual, p. 24. BERZELIUS, Annual Progress of Chemical and Physical Science. (Edinburgh Journal of Science, Vol. 3, New Series.)

‡ Some local exceptions around elevated mountain ranges are well known, as around the Alps, and the northern primary region of New-York; and it is probable that others will be discovered.

of some hundreds or thousands of feet more than at present; and by their having been deflected in their courses of transportation (as the scratches show,*) by the topographical features of the country, which could not have been the case if they had been drifted by the wind in still water, on ice.

(*c.*) We know of no other cause than currents of water, that *could* have produced effects like those *observed;* namely, transportation to great distances, rounded masses of rock, scratched surfaces of solid rocks in place, and the scratches in such directions as the topographical features of the country would give to currents.

We may therefore adopt the conclusion as almost certain, that currents *have* flowed from the polar regions of the *north* towards the equator; and as far as we have evidence from the observations of Darwin, and others, on the boulders and blocks of the southern hemisphere, that similar currents have flowed from the *south* polar regions towards the equator. Both arguments lead to the same general result. It will be shown subsequently that there *are* dynamical laws that must necessarily have caused currents, such as we see the effects of, through all time since the ocean has existed, and which would be heightened in effect by the refrigeration of the globe, and will render the evidence of refrigeration still stronger.

It is evident from the phenomena observed, that a change in the relative levels of the ocean and the land *has taken place since the epoch of the transportation of the drift deposits;* and of the physical causes to which such a change of level may be ascribed, we are bound by sound reasoning to exclude all that are *exterior* to the earth.

Prof. John Phillips has shown, "that the desiccation of the land is not the effect of the general cooling of the globe *without change of form;* for the effect due to that, is of a contrary description: nor of the unequal contraction by cooling of the superficial parts of the globe; for that effect, even through the whole range from boiling heat (212°) to 40° F., would be totally inadequate to account for the phenomenon, even if the depth of the ocean be supposed far greater than it is admitted by astronomers to be."†

The desiccation of the land, and the occurrence of tropical animals and plants found fossil in the cold regions of the earth, have been attempted to be explained by a change in the axis of rotation, by which the polar regions would be brought under the equator. Such a change would cause a flow of water from the polar regions, to maintain the earth in the form of an oblate spheroid, such as is due to the velocity of rotation of the earth; and without a change of form of the solid exterior of the earth, must have buried the equatorial regions under a depth of several miles of ocean, and left the polar regions as highly elevated tracts of land. This theory would well account for many of the facts of the drift period, but it labors under an objection that is insurmountable. Astronomical observations and calculations not only afford no support to it, but demonstrate its impossibility, and show that the axis of the earth's rotation is fixed.

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* The boulders show the general *result* of the direction of transport, the scratches, both the general and local directions. The scratches generally conform to the main valley in its lowest part, but are laterally oblique in most instances on its sides, and are more or less approaching to a perpendicular direction in the transverse valleys.

† PHILLIPS, Treatise on Geology. Edinburgh, 1838, p. 279.

It has already been remarked, that there are no known evidences that there has at any time been more water upon the surface of the earth than at present. It follows from the various facts known, that the relative levels of land and water have changed, and consequently the land must have been elevated, or the bed of the ocean sunk, or both effects more or less extensively produced.

The only causes to which we can ascribe such relative changes of level, that have not been considered, are, 1, Some force acting beneath or within the crust of the globe, that tends or has tended to elevate some parts; 2, The collapsing of the crust of the globe upon its contracted nucleus irregularly, producing elevation in some parts, and depression in others. The powerful lateral thrust in such a case would be amply sufficient to elevate mountains, mountain ranges or continents, and produce all the phenomena of contortion, wrinkling and folding of the strata. The phenomena of earthquakes and volcanoes would also flow from the same cause, and afford a plausible and perhaps true explanation.

That one or both of these causes have operated in times past, and will continue for time to come, can scarcely be doubted. The phenomena from one of these causes, necessarily follow from the refrigeration of the globe, a point concerning which there can be no doubt. From the other cause, phenomena similar in character may probably result; but we know of no cause that could produce such effects, except the fractured surface allowing water to penetrate to the heated interior, to generate steam sufficient in tension and quantity to effect the results; and we know not how the crust could be fractured, except by contraction, and collapse upon the contracted nucleus.

That the same portions of the crust of the globe have been successively elevated and depressed, is beyond all doubt, from the facts observed by geologists, and numerous local facts of this kind have occurred within the historical period; but the geological evidence of similar facts on a vast scale, is as strong as if it had come under the *direct* observation of man. That elevation of one part was accompanied by *depression in others*, is probable; but the evidences of depression are not so easily obtained, as we must look in the sea and on coasts for them.

"From Mr. Hopkins's researches, it appears that the elevatory agency was of the nature of a gradually augmenting force, very extensive compared to the areas simultaneously disturbed. No example of modern earthquakes can be brought to render it probable that mere volcanic agency could upraise the continents which it is capable of shaking. Yet as far as we see, a more powerful exertion of the same kind of agency might perform the effects; the principle of this, and every other explanation, being the necessity of a new adjustment of the exterior form and dimensions of the globe in consequence of accumulating tension upon it.

"But if, for a moment, we abstract our attention from these limited developments of the energies of heat, and consider the elevatory action below continents and islands as the local resultant of diffused subterranean forces, it appears possible to arrive at a general and more applicable theory. If, as observations seem to indicate, the ocean once covered all or a large part of the globe, its mean depth must have been less than at present. Since the inequalities of the land arise from subterranean convulsions, and the bed of the sea is very irregular, we may admit that the whole, or nearly the whole of the terraqueous area, has been affected by local

displacements. *It is the resistance offered by the consolidated crust of the globe to a gradually augmenting* CHANGE OF INTERNAL DIMENSIONS, *which caused the disturbing movements.* We may therefore allow, that before the production of a consolidated crust of the globe, the ocean (if it existed in a liquid form) was spread with considerable uniformity over the spherical surface.

"From these postulates, it must follow that the actual bed of the sea has been formed by displacements, which upon the whole have caused a real subsidence; as the displacements of the land have, upon the whole, caused a real elevation of it. And our confidence in the assumed condition is augmented by observing, first, that they are all implied in the inferences from phenomena already adopted, and that they agree with the sentiments of astronomers as to the relative depths of the sea to the heights of the land.

"In endeavoring to embrace the phenomena of elevation and subsidence in one point of view, it appears almost immaterial whether we suppose the tension of the consolidated crust of the globe, which preceded its fracture and displacement, to have arisen from inward or outward pressure—from expansion of, or contraction upon the interior nucleus; because, in each case, the pressure would be of the general and gradually accumulating description required: but it seems an unavoidable condition, that *the interior nucleus should be of a yielding nature,* to permit the subsidence of large portions of the surface, and accommodate itself permanently to the elevations. This condition leads us to the supposition of great interior heat, which, from general physical considerations, had before appeared very probable, and, from experimental researches, almost a matter of certainty.*

"If then we regard this heat as variable, (and, placed as the hot globe is in the vast cold regions of space,† through which it radiates its uncompensated rays, it must be so—the globe must be growing cooler,) and we have at once the general physical cause of the phenomena of disruption and displacement on the crust of the globe, viz. A COLLAPSE OF THIS CRUST UPON THE INTERNAL NUCLEUS SLOWLY CONTRACTED BY REFRIGERATION."‡

This must have occurred either at intervals by paroxysms, when the action of gravitation became too powerful for the resisting force to withstand, causing subsidences in some parts, elevations, contortion and wrinkling of the strata in others; or in a more uniform subsidence upon the contracted nucleus, producing the same effects, but in a slow, and perhaps to human observation almost insensible manner. The diminished diameter would necessarily change the length of our day, rendering it shorter; but the observations and calculations of astrono-

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* Perhaps these, with the evidences of polar currents heightened in their effects at particular epochs, may be considered as giving it all the certainity that is attainable with our present knowledge of the earth.

† Three different modes of calculating the temperature of space, gave the following results:

Fourier, = — 50°.00 centigrade.
Svanberg, = — 49°.85 "
Ditto, = — 50°.35 "

From Lambert's statements on the absorption that takes place in a ray of light passing from the zenith through the atmosphere. Vide De la Beche's Manual (Phil. 1832, p. 24); Edinburgh Journal of Science, Vol. 3, New series.

‡ PHILLIPS. Treatise on Geology. Edinburgh, 1838, pp. 281, 283.

mers are considered as having demonstrated that the length of our day has not varied a minute fraction of a second of time during the last two thousand years. Hence any sensible change in diameter, and consequently any increase of centrifugal force that should cause a flow of water from the polar regions towards the equator, with a more rapid current than that due to present causes, must have been antecedent to that time. This length of time having made no sensible difference in the length of the solar day, might be urged as an objection to these views; but mathematical investigations upon the laws of the refrigeration of heated bodies, and applications of those laws to the cooling of such a body as the earth, with the conducting and radiating powers of the materials forming those parts that have come under the observation of man, and with the temperature that it is known to possess, have shown that the *time* required to make any *sensible difference* in the mean temperature of its surface would be very great (almost infinite); and if such intervals are required for changes only *sensible*, what would they be for such changes of temperature as we have undeniable geological evidences of, in tropical plants and animals found in rocks of ancient date, even under the polar circles, and in the interior temperature of the earth, from observations in mines, artesian wells, and on hot springs and volcanoes; and hence the time of two thousand years may be considered as the *differential* of such periods as geological phenomena and philosophical laws lead us to conclude have passed during the different geological epochs.

Causes of polar currents.

There are three supposable causes of currents flowing from the polar toward the equatorial regions, capable, it is believed, of producing all the effects and phenomena of the drift deposits, under the supposition that the land was mostly covered by water, viz:

1. That arising from the refrigeration of the globe.
2. That of the upheaving of large bodies of land or mountain ranges in the polar regions.
3. That of the polar currents to restore the equilibrium, disturbed by the gulf stream and the difference of temperature of the water in the equatorial and polar regions.

The first of these, arising from the effects of the refrigeration of the globe, has already been discussed, and found sufficient to produce currents from the polar regions towards the equator.

On the second of these causes, namely, that of upheaved masses of land or mountains, at the period of the drift deposits, in the polar regions, we have no satisfactory evidence. Investigations have not been made in those regions of the earth's surface, sufficiently minute for drawing any conclusions; and the only evidence, that, as far as we know, would afford it any support, is, the effects observed farther towards the equator, in boulders and blocks transported in those directions, and scratches and abraded surfaces on the rocks in place, indicating a flow of water towards the equatorial regions. So long as there are *causes sufficient to explain the effects*, and on which there is *strong and undoubted evidence*, those *possible causes* on which we have *no satisfactory evidence* may well be discarded.

The third cause is as permanent as the existence of the ocean, and the rotation of the earth on its axis. The equatorial current (which, in the Atlantic ocean, after being deflected in its course by the eastern coast of South America, through the Caribbean sea and the Gulf of Mexico, into the North Atlantic, is called the *gulf stream*,) disturbs the equilibrium of the spheroid (the earth), rotating with its present velocity, and requires a compensating current from the polar regions to restore it. Another reason for a polar current, is, that the waters of the ocean under the equator being more heated, *expand, and become specifically lighter;* and although this cause may be scarcely appreciable, still it undoubtedly has an influence in a tendency to add to the equatorial current, and slightly increase its flow towards the polar regions, similar to the more marked effects that *we know* are produced by the same causes acting on the atmosphere.

Mr. Redfield has shown* that the Polar or Labrador current is continued southwest along the coast line of the United States; and that it is not an *eddy*, in the usual acceptation of the term, but that the Gulf stream is superimposed upon and contained in this current. They flow in opposite directions, as we often see the clouds at different elevations, when moved by different currents in the atmosphere. The Labrador current brings the ice islands and drift ice from Davis's strait; and "in its progress to the lower latitudes, is kept in constant proximity to the American coast, by the dynamical law or influence which, in the northern hemisphere, caused all currents which pass in a southerly direction to incline towards the west, in consequence of the increasing rotative motion of the earth's crust in the opposite direction, as is the case of the trade winds in the lower latitudes."*

The drift ice of the Northern Atlantic is always found in the western part, and is believed to have been rarely if ever seen east of 42° west longitude from Greenwich,† notwithstanding the powerful influence of the prevailing westerly winds. It is brought under the melting influence of the gulf stream in the vicinity of the Banks of Newfoundland, and is still carried southward by the same current which flows beneath the gulf stream, the superposition being determined by the relative temperatures.

These currents (the Labrador current and the Gulf stream) are but local examples of the currents that act as means of compensation, tending to restore the equilibrium of the rotating spheroid (the earth), disturbed by the various causes mentioned, namely, the secular refrigeration, the inertia of the ocean, and changes of temperature in the waters of the ocean. There may also be other causes.

The causes that have been mentioned must have produced similar effects through all time since the oceans have existed, and they may be calculated on to produce similar compensating effects through all time to come. We may therefore reason upon the effects that may have been produced in times past by such causes; and in doing so, I now purpose to confine the reasoning to North America; not that the same train of investigation will not be applicable

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* Redfield American Journal of Science, Vol. 32, p. 350.

† Nautical Magazine, March 1837, p. 139. American Journal of Science, Vol. 32. p. 351.

to other parts of the earth's surface, but because the facts upon which the arguments are based are more familiar to me, and have come mostly under personal observation.

It cannot but be admitted, from the various facts detailed on the transportation of boulders and drift, and the scratched surfaces of rocks, first, that the topographical features of the country were, at the drift period, in the main, the same as at present; secondly, that the same dynamical law that *now* causes the Labrador current to trend to the westward along the American coast, acted in former times when most parts of the United States were buried beneath the waters of the ocean; and thirdly, that the same dynamical law that causes the flow of the Gulf stream, must then have caused a part of that stream to flow from the Gulf of Mexico through the Mississippi valley at the drift period; and owing to its greater rotative velocity in the tropic than as it progressed towards the north, it would have a *tendency* to an eastwardly flow from that valley.

To the action of these two currents as main causes, influenced by the dynamical laws above referred to, and the topographical features of the country, when mostly beneath the waters of the ocean, we would ascribe the phenomena of the drift deposits.

Influences of these currents in the distribution of the drift.

The northern current from Hudson's bay and the Polar seas, with its ice loaded with northern rocks, flowing over the northern parts of the United States, would be met by the warm waters of the Gulf stream, and cause most of the freight of the ice to be deposited within a few degrees of latitude, as we see in the ocean at present. To this cause I ascribe the vast amount of the drift deposits of Ohio, Indiana, Illinois, Northern Missouri, Iowa territory, Wisconsin territory and Michigan; as the main valley of communication between the Polar seas and the Gulf of Mexico is through the Mississippi, Upper Mississippi and St. Peter's, and Red river of the North, to Hudson's bay and Mackenzie's river. This great valley is several hundred miles wide in some parts. The warm current would flow on to the northward, superimposed on the cold current which would continue southwards beneath the other, and transport fine materials, as we see in the Mississippi valley, of the detritus of rocks far to the north, as has been already explained.

The eastwardly tendency of the Gulf stream arising from an obedience to the dynamical law, influencing its rotative velocity derived from its inertia, would cause the current to be deflected from the Mississippi valley. The main outlet of this part of the Gulf stream, flowing up the Mississippi valley, and bearing to the eastward, would be through the valley of the Great lakes, across Illinois, Indiana, Michigan, Ohio, Missouri, Iowa and Wisconsin; and to the influence of this warm water from the south, I attribute the scarcity of erratics south of the Ohio and Missouri, and of the elevated region in Pennsylvania and New-York, south of the Lakes Erie and Ontario and the Mohawk valley, to the Catskill mountains.

There can be no doubt, on a review of the facts narrated, that the scratches on rocks are due to the movements of floating ice, containing masses of rock frozen in, and grinding upon

the bottom. The glacier theory, however applicable it may be in particular localities, will not apply to the broad level tracts of country like Ohio and Western New-York, where the rocks show no signs of disturbance of an amount appreciable to the eye, since their original deposition; and the phenomena of scratches of the northern parts of the United States are evidently all due to one general cause.

The scratches in Ohio and Western New-York are generally in a west of north and east of south direction; and as there are *there* no topographical features of the country that are obvious reasons of the directions, we may refer to the general tendencies of the currents. It has been shown that the general tendency of the current from the south is towards the *east;* and this, meeting bodies moved by the *northern current*, would necessarily give to those bodies a new direction as the resultant of those forces; or the currents themselves may be so blended as to give a new direction to both, and to bodies floated by them. In either case, the resultant of those forces (in which the floating body coming from a northwardly direction would be moved) would be to the eastward of south, depending for its direction upon the exact direction of the acting forces, and the relative amount of surface exposed to the action of each of them. This is believed sufficient to account for the directions of the scratches in Western New-York and Ohio, with some local exceptions, that may perhaps be dependent on local causes. Those of Wayne, Monroe and other counties, in a north-northeast and south-southwest direction, may be due to the action of the northern current through the St. Lawrence valley, and easterly trend of the other current through Lake Erie.

The extension of the warm southwardly current* would tend to pass on eastwardly through the country of the north and south lakes of central New-York, and the Mohawk valley; while the underlying cold current from the north and from the northeast through the St. Lawrence valley, would press its drift southward upon the elevated lands on the south, and through the defiles into the present valleys of the tributaries of the Susquehannah and Allegany.

In the valley of the Mohawk (which is south of the high mountainous primary nucleus of the northern part of the State), the easterly trend of the current from the south which we have traced, mingled more or less with the northern current, but uninfluenced in direction by it there, must have passed through the deep and broad valley of the Mohawk; and any scratches made by bodies floated by that current, must necessarily conform more or less nearly to that valley, except where there were lateral valleys to the south, through which materials drifted on the surface would necessarily float with these secondary currents to the south. Such effects in drift deposits, and smoothed and scratched rocks, with the scratches directed to the southward, are observed in the summits of all, or nearly all the north and south valleys leading from the Mohawk valley to the tributaries of the Delaware and Susquehannah, and from Western New-York to the tributaries of the Susquehannah and Allegany.

The main current, on emerging from the Mohawk valley, and meeting the current from the north flowing through the Champlain and Hudson valley, would have its direction changed

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* Perhaps a part of it may have passed through the St. Lawrence valley, but it is more probable that that valley was occupied by the northwardly currrent.

to the southeastward in its upper part, as we see the scratches are directed on the elevated grounds in the eastern parts of Rensselaer and Columbia counties, and in the western part of Massachusetts; and this upper current would continue to influence the direction of scratches on the high grounds to a gradually diminishing extent to the eastern part of Massachusetts and Connecticut, yielding more and more to the influence of the northern current through the Connecticut, Merrimack and other valleys, and which would more or less impress its direction by scratches in the lower part of the valleys.

The Mamakating and Walkill valleys forming the Great valley, an extension of the Champlain and Hudson valley, from its southwestwardly trend, would be in the natural direction of the set of the northwardly current. The scratches in this valley, and on the sides of the mountains, as well as those similarly situated in the Hudson valley, and on the island of New-York, conform to what we should expect from the flow of a *superior* current from the westward, and an *inferior* current from the northward, modified in direction by the topographical features of the country. The scratches seem to have been formed by rocks frozen in ice, drawing a sufficient depth of water to be influenced by both currents; those drawing the most water, having been most influenced by the under current towards the general trend of the valley; those drawing less water, more influenced by the superior current, tending southeastwards obliquely across the north and south valleys.

In describing the surfaces over which the currents have acted in the United States, I have considered them as acting mainly through certain valleys; but there can scarcely be a doubt that they acted more or less extensively over nearly all the country, with the exception of Eastern Ohio, most of Pennsylvania, part of the southern mountainous portions of New-York, and the mountain region extending southwest through Maryland, Virginia, the Carolinas, Tennessee, and the northwest corner of Georgia, into Alabama; the higher parts of the northern primary region of New-York, and the more elevated primary regions of New-England.

Another branch of the Gulf stream (of which we have evidence that will be adduced in its proper place) undoubtedly flowed parallel to the trend of the mountain region across Florida, Alabama, Georgia, the Carolinas, Virginia, Maryland, Delaware, the eastern parts of Pennsylvania, New-Jersey, New-York, Connecticut, Massachusetts, New-Hampshire, Maine, and the Provinces of New-Brunswick and Nova-Scotia.

To the eddies formed by the meeting of this coast stream from the south, with that through the valley of the Lakes, the Mohawk, &c. and the St. Lawrence valley, modified also by the northern currents bringing ice rafts laden with rocks and earth from the north, I would ascribe the extensive and thick deposits of drift of New-England and Long island, and *other parts* where the warm waters of the Gulf stream thawed much of the ice brought south by the northern currents. It will be observed that no erratics, or scarce any, are found south or south-southwest of Staten island for a considerable distance from the coast, the Gulf stream having held there an almost entire preponderance; while in Long island, Connecticut and

Massachusetts, where the inflence of the western and northern currents were also felt, the results are very obvious.

The diluvial elevations and depressions of Prof. Hitchcock, or round-backed hills with bowl-shaped valleys, remain to be explained. I must confess my inability to do it satisfactorily. Effects somewhat similar are produced where sand and snow are drifted along a surface on which there are slight obstacles, as gravel, pebbles or grass. Eddy currents of wind or water pile up materials drifted by them in a manner somewhat analogous, but the particles in all these cases are nearly uniform in size; but in the drift hills, the materials are of all sizes from large blocks and boulders to sand and clay.

Circumstances were related by Capt. ——, of the effects produced by icebergs grounding, and which would seem to offer a satisfactory explanation of the drift hills and valleys.* An ice island, when aground, grinds upon the bottom; the earth and rocks frozen in its mass are gradually disengaged, and fall or are washed off, and sink to the bottom beneath and around it; and as the upper parts, where exposed to the warmer surface waters, melt most rapidly, it occasionally tumbles over. The materials sinking around it, and the grinding of the mass of ice in its bed by the action of currents, or by gyrations from changes of the centre of gravity, seem a plausible explanation of the phenomenon of the drift hills and valleys. A strong objection may be urged against it, and it applies with equal force to the transport of the drift deposits generally. The objection is, that if this be the explanation, we must infer that either the drift deposits of the diluvial elevations and depressions are composed of rocks from far to the north, where icebergs are supposed to have been formed; or, that icebergs and glaciers have been formed on all the elevated lands of the country.

Observations have shown that the greater portion of the drift is composed of such materials as exist in place at no great distance. Local ice, such as we now see formed and transporting detritus, although sufficient to afford a *partial* explanation of the transport of some of the drift, yet is not capable of explaining the phenomena of diluvial elevations and depressions as formed by icebergs; neither will local ice such as we now see formed on our shores, suffice to have caused the scratches at great depths below the surface, as it is evident from the facts observed, must have been effected.

Glaciers and icebergs, if they *had* been formed on our coasts, would not, in fact, be sufficient to account for *all* the phenomena; for the drift deposits are composed of rocks existing at all elevations, from the present tide-water level, to the tops of the high mountains; and glaciers and icebergs formed on the coasts as they then existed, could not have been formed as they are *at present supposed to be formed*, so as to enclose rocks at all these various levels, when most of the present land was deep below the level of the ocean.

The formation of *ground ice* is the only supposition we are authorized to make, and on this subject there is little *positive* information. It is known to form where the water is more than one hundred feet in depth, and to raise from the bottom great quantities of earth and

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* American Journal of Science, Vol. 41 or 42. I have not the volume, and there is no library near that has a copy; so I cannot give the language or name of the author of the observations.

rock, and to float them off to distant parts. Ground ice, if formed in thick masses and moved by the currents, would afford an explanation of most of the phenomena of transport of the drift, and of scratches; but it would not explain the elevations and depressions of drift, unless floated along beneath the surface, or in masses of very great thickness. On this point we have no direct evidence. The phenomena of ground ice are worthy of investigation. It is by means of this ice only that all the phenomena of the drift can be reconciled, as far as we know at the present time.* This would seem to imply a temporary change of climate at the drift period; for ground ice is not, so far as we know, formed abundantly, as we might suppose it to have been in many places in southern New-York, where we have undeniable evidence that erratics from varied altitudes have been transported many miles.

It has been shown from physical considerations that the earth is contracting in diameter, and consequently increasing in its velocity of rotation, either steadily or paroxysmally, probably both. A *sudden* yielding of the crust, would produce a *sudden acceleration of rotation*, and *a sudden acceleration of the great equilibrating currents* of the ocean; and such an occurrence, when our country was mostly beneath the ocean, would tend to cause vast quantities of ice to be transported from the polar regions to those parts where we find the erratics. This ice would have a tendency to *alter the mean temperature of the climate* under its influence, rendering it colder, and sufficient, it is believed, to account for the phenomena of local drift, by means of local surface ice and ground ice.

It is probable that a sudden acceleration of the velocity of rotation of the earth, so small as to be scarcely capable of measurement, except by long continued observation by astronomers,

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* Sand is frequently found cemented by ice in cold weather, in rivers. Gravel, earth, and mud, have been found in ice floated to the shore, that has risen from the bottom. The spiculæ of ice, by a polarity under certain circumstances, become aggregated rapidly into great masses. Fishermen have often observed such facts; and frequently, in frosty weather, their anchors drag over the smooth icy bottom. The anchors when raised are sometimes coated with ice; and it sometimes forms on them in such quantities as to raise them to the surface by its buoyancy. Ice is frequently raised by them, instead of fish on their hooks. Sluices and flood-gates are often rendered immovable by ice formed at the bottom. Ground ice often attains a great thickness before it rises to the surface, and raises by its buoyancy not only stones, earth and gravel, but large rocks. In the River Elbe, the rocks to which buoys have been attached on shoals, have been raised by the ground ice, and floated to other parts of the river.

M. Brauns, after consulting with much care the best sources of information, learned that in the northern seas, both the ground ice and the grain ice (which rises in grains like hail to the surface) were found where the depth of water was one hundred and eight feet. In the Baltic sea, the ground ice was found at depths still greater. Some additional observations have been made in England, by Mr. Knight.

Vide Phil. Trans. London, 1816; and Mr. Mease, Edinburgh Encyclopædia, Phil. Vol. 11, p. 70.

Vide also, on ice,

Demarest, Journal de Physique, Jan. 1783;
Hassenfratz, Id. Jan. 1785;
D'Antic, Id. Jan. 1788;
M. Jules-Henri Pott, Id. July 1788;
M. Hericaut de Thury, Journal des Mines, 1813, Vol. 33, p. 157.
Scoresby, in the Memoirs of the Wernerian Nat. His. Soc. of Ed. Vol. 2, part 2.
Col. Beaufoy, in Thomson's Annals, May, 1817.

would be sufficient to cause the detachment of vast quantities of ice in the polar regions, and its transport towards the equator by the polar currents; and the acceleration of currents from such causes are capable of an approximative calculation.

Summary of Conclusions on the Drift.

On reviewing all the facts on the phenomena of the drift, I am led to infer,

1. That the transport of drift, and the production of scratched and smoothed surfaces, the belts of boulders, and the gravel and boulder hills, or diluvial elevations and depressions, were contemporaneous.

2. That the drift was transported by the AID of CURRENTS, *but not by them exclusively;* since enormous blocks could not have been transported by them alone without removing beds of gravel, sand and clay, on which many of them rest. Neither could the theory of glaciers account for them in level countries, nor for the scratches hundreds of miles from any elevated lands, on strata that show no signs of disturbance since their formation, as is the case in Ohio and the Western States, and in the western part of New-York.

3. That ice, aided by currents, has been the cause of the transport of most of the drift, which has been dropped where we find it (in consequence of the thawing of the ice); diffused in scattered blocks, boulders and pebbles; collected in belts, like an ancient shore; in groups, where a raft of it had grounded; in gravel hills and valleys, with boulders and blocks, where ice islands had grounded and dropped their burthen around them, or where eddy currents had kept them floating over limited areas, as we see in many valleys, and on Long island, the east and southeast parts of Massachusetts, and various other parts of the country.

4. That the same causes continued to act after the drift epoch, during the quaternary period, but modified in force, in consequence of a partial emergence of the land from the ocean, obstructing the free flow of water over the higher lands, and confining it within certain limits in the present great valleys of drainage in North America.

5. That the periods of the drift and quaternary deposits were separated by this partial emergence of the land, altering the relative levels of the sea and land.

6. That the causes of the transport of the drift, and all the phenomena of that period, may be referred to the temperature of the earth, and the dynamical laws regulating its motions.

7. That the periods of the drift, and of the upper drift, were periods when the currents were stronger than at the intermediate and the present times, caused by collapse of the crust of the globe upon its nucleus by refrigeration, causing an acceleration of the velocity of rotation; and this, a consequent disturbance of the form of equilibrium of the spheroid of rotation, which would be compensated by the flow from the polar regions, and an accelerated flow of the equatorial currents.

8. That there was a temporary change of climate at those periods.

SUPPLEMENT TO THE QUATERNARY SYSTEM.

ALLUVIAL DIVISION.

Some omissions were made in the descriptions of the alluvial and quaternary divisions. They are supplied in this supplement.

Localities of Marl.

[I have not seen the localities here mentioned.]

COUNTY.	LOCALITIES AND REMARKS.
Washington.	Baker's falls. Vide { Cleaveland's Mineralogy, p. 190; Webster's Catalogue of New-York Minerals; Robinson's Catalogue of American Minerals, p. 116.
Albany.	Bethlehem. Ib. p. 116.
do.	Helderberg. Ib. p. 131.
do.	Coeymans. { Ib. p. 123; Webster's Catalogue of New-York Minerals, p. 6.
Greene.	Catskill. American Journal of Science, Vol. 3, p. 236.
Rensselaer.	Sand-lake. Ib. Vol. 8, p. 36.
Saratoga.	— Steel's Survey of that county.
Ulster.	Marbletown, and containing bones. { Webster's Catalogue of New-York Minerals, p. 29; Cleaveland's Mineralogy, p. 190.
Queens.	Newtown, Long island; said to be marl, and formerly used for whitewashing; perhaps infusorial earth.

Peat.

Peat occurs in the heads of the ponds in the Shinnecock plains, one and a half miles southwest of Southampton; Coldspring bay, several places in quantity; Canoe place; Bull-head bay, and around a bay between the last and Toad bay, in quantity; and in the mill-pond above the head of Mecock bay. These localities are all in Southampton. Peat, sometimes of inferior qualities, is found in considerable quantities in such situations as these mentioned, around the whole coast of Long island, in places too numerous to particularize.

On the Origin of Peat. By Dr. Mitchill.

In 1798 or 1799, Dr. Samuel L. Mitchill was appointed a commissioner of the Agricultural Society of the State of New-York, to make an examination of its soils, rocks, etc., with a view to the promotion of the agricultural interests of the State.

In his report,* he was the first to make known the true origin of peat or turf, the nature and origin of which had before been misunderstood.† Speaking of peat as an alluvion, he says, "This is frequently of an inflammable nature, and answers very well for fuel. When used for burning, it is called *peat* or *turf*. If employed in fertilizing the ground, it is termed *swamp manure*. The true history of this substance has not been generally well understood, for it has been commonly classed with mineral substances, though Mr. Kirwan, who retains it in his mineralogy ‡ (Elements, &c. Part 3, Sp. 11 and 12), has removed it from the class of *earths*, where it had been placed before, to the class of *inflammables*. 'There are,' says he, 'two sorts of inflammable substances known by the name of *peat*. The first and principal is of a brown or black color, found in a moory ground, and when fresh, of a viscid consistence, but hardens by exposure to the air. It consists of clay, mixed with calcareous earth and pyrites, and sometimes contains common salt. While soft, it is formed into oblong pieces, and the pyritaceous and stony matters are separated. When distilled, it affords water, acid, oil, and volatile alkali, and its ashes contain a small quantity of fixed alkali. They are either white or red, according as it contains more or less ochre or pyrites. It is found in Scotland, Holland and Germany. Another sort is found in Newberry, in Berkshire. It contains but little earth, but consists chiefly of wood, branches, twigs, roots of trees, with leaves, grass, straw, and weeds.' '*Turf* consists of mould interwoven with the roots of vegetables. When these roots are of the bulbous kind, or in large proportion, they form the looser and worst kind of turf; but when mixed with a considerable proportion of peat, form what is called *stone-turf*. It at first hardens, but at last crumbles, by long exposure to the air.'

"An accidental occurrence satisfied the mind of the commissioner, as to the particular plant entering largely into the constitution of peat bogs. Some time in the year 1786, as he was travelling in the western parts of Scotland, after his return from the Highlands, in company with two of his friends, they directed their walk on foot from Greenock across the country to Paisley. During this excursion, they crossed an extensive bog of peat or turf, not far to the westward of this town; and there remarked for the first time, that the uppermost stratum of peat consisted of small plants, which, though dead, were in a state of entire preservation. Their particular shape, their genus and species, could be plainly distinguished. The principal among them was the *Sphagnum palustre*, which, upon examination, constituted almost the whole of that deep and extensive bog. On examining beds of turf in America, the same observation has been verified, by numerous observations of these plants, in their living as well as decayed state. He thinks himself warranted in concluding the basis of peat and turf to be the sort of moss called by Linneus, *Sphagnum palustre* (Sp. Plantar. p. 1570), 'which,' that author says, 'grows in the deep bogs and fens of Europe.'

"This plant delights to grow in wet, low, or swampy places, and requires for its support a plentiful supply of water. It will also thrive in elevated situations, if sufficiently moistened;

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* Vide Medical Repository, New-York, 1800, Vol. 1, pp. 279, 431; Vol. 3, p. 435; Vol. 5, p. 212. † Ib. Vol. 1, p. 432.

‡ The term *mineral* at the present time includes all natural inorganic substances, and peat as an organic combustible alluvion.

for on high mountains, where water is so plentifully condensed as to preserve constant wetness, the *sphagnum* grows vigorously. When a plantation of these vegetables is formed on a low-land bottom, the parent plants, after producing and maturing their seeds, die, and form a soil for their offspring to grow upon; for, as it has been long ago ascertained that some vegetables can grow without being rooted in *earth*, it is here found, that *dead moss* answers all the purposes of a soil for the new generation of moss to grow upon. After a while, this crop of plants dies, and adds to the increase of the vegetable matter beneath; and thus, from year to year, the process goes on, the old plants decaying, and forming a soil for the seeds they left to sprout in; until, by degrees, a bog of moss be formed. And this happens, because the plant which had lived in water does not very speedily corrupt in it, but continues to accumulate layer upon layer. It hence follows, that the depth of the bog will be proportional to the number of successive decays of these swampy productions, and to the circumstances favorable to their thriftiness.

"In its fresh and living state, it retains water like a sponge; and, on account of its being so retentive of moisture, it becomes a soil for aquatic plants of various sorts, which absorb nourishment from the water, and other matters inherent in the moss. These vegetables taking root, growing in the peat, and decaying there, give to it the mingled appearance of roots, leaves, stalks, branches, bark, trees, and other extraneous substances, so frequently blended with it.

"When peat is left to itself, to grow in the natural way, it frequently rises many feet above the original surface of earth; and the stratum continues to enlarge and thicken, as long as there is water enough to keep the moss alive. When this fails the plants die, and the process stops; for, after it is raised considerably above the level of the springs that feed it, the rain of the season is neither regular nor copious enough to supply the demand both of it and the plants rooted on it; they consequently perish. Therefore, the ditching of swamps and meadows where the sphagnum grows, will drain off its requisite supply of water, and quickly destroy it; and it is accordingly observed, that where such low lands are, by art, rendered fit for manuring, pasture, or tillage, the growth of peat is stopped, and a sward of grasses is formed above the inflammable matters, which is thereafter wholly concealed from sight, and is never to be seen until after the sod is dug away.

"As the peat is thus formed, layer over layer, in the course of successive vegetations, it can be easily explained how trunks of trees, fossil wood, and bodies and bones of animals, came to be buried so deep below the present surface; because, at the same time when the trees fell, and animals died, in the places where they are now found, they were upon the top, and, by the perpetual growth of the plants around, they have, in many places, become covered to a great depth.

"If there is any difference between peat and turf, it consists in the degree of putrefaction, to which the former has been subjected more completely than the latter; and has lost, therefore, more of a vegetable appearance, and become more completely divested of its organic nature. As the other vegetables growing in the sphagnum have, each of them, somewhat of peculiar qualities, it must follow, that *turf*, when chemically examined, will afford a greater

difference of result; and this variety will be rendered yet greater by the mixture of earths, stones, and other mineral substances, which the winds and torrents have carried among it.

"From all these particulars it will be apparent, that both turf and peat, when pure, ought to be considered merely as a residuum of decayed vegetables; that the minerals frequently found in it are foreign and casual admixtures, by no means essential to its nature, and that it ought not to be considered as a mineral production, nor classed as such in the systems; but that the clay, marl, pyrites, and other fossil bodies found among it, should be referred to their proper places in the mineralogical arrangement.

"On this subject there appears a propriety in suggesting a few practical hints. As wood grows scarce, and our State is not known to abound in coal, the sphagnum might be cultivated for fuel in wet grounds and swamps that now lie waste, and perhaps will never be cultivated. If this should ever be attended to as an economical matter, the cultivator should not suffer cattle to tread it, nor foreign plants to overgrow it, nor water to be drained from it; but clear the swamp of the peat as soon as it has risen above the moistening influence of the springs, and be ever careful to remove the upper paring, containing the living plants, to some wet and suitable spot for propagation.

"But though the sphagnum has so much agency in filling up wet and low places, it is by no means the only plant which acts in that way. There are many other small and obscure vegetables, which, by their numbers, add considerably to the bulk of matter accumulated in these spots. Many of the grasses taking root, and increasing upon such bottoms, form, in process of time, bogs, hassocks, or a sort of sward, which contribute no less to the diversity than to the increase of these swampy productions. When shrubs and trees of various kinds, as well as annual plants, gain an establishment in these soils, the qualities and appearance of the latter undergo additional variation."*

Mastodon.

Bones of the mastodon were found in 1790 – 91 and 1800, in the town of Montgomery, about twelve miles from Newburgh in Orange county. They were ten feet below the surface, in a peat bog in marl. Several bones of the legs, some of the vertebræ, several ribs, and some of the bones of the head, were obtained. One of the leg bones "measures more than forty inches around the joint, and thirty-six on the cylindrical part of the bone, and is nearly five feet long. The teeth are nearly seven inches long, and four broad; they are found white, and fast in the jaw, without appearance of decay. The holes in the skull, where appears to have been the nostrils, measure eight inches in diameter. The orifice occasioned by the decay of the marrow, in the back bones, three and a half inches in diameter." "Eight similar skeletons have been discovered within eight or ten miles of the neighboring country, and some of them were fifteen or twenty feet below the surface of the earth."† All these specimens were

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* Medical Repository, Vol. 1, pp. 431, 435.

† S. Miller. Medical Repository, N. Y. 1801, Vol. 4, p. 212.

discovered between 1790 and 1800. Some bones of these animals were found in 1782, three miles south of Ward's bridge in Montgomery, Orange county; another locality one mile east of the above bridge; another three miles east; another seven miles northeast; another seven miles east; another five miles westwardly from the same bridge; and another ten miles north of the same bridge, in the town of Shawangunk.*

Bones of these animals were found in digging the Delaware and Hudson canal, in a peat bog between Red bridge and Wurtsboro' in Sullivan county. Fossil bones of the mastodon and fossil elephant have been found in other parts of Orange county, and probably other counties in the First Geological District; but either no records have been preserved, or I have not seen them.

Drifting Sands.

Nepeague beach, which connects Long island with the eastern part, (which was once three islands separated by Great-pond bay, Fort-pond bay and Nepeague bay,) is mostly drifting sand, piled up into little hills and ridges, with marshy places and wet sand between. Much of the water of these places is tinged with iron, from changes in composition of the ferruginous parts of the sand. Between the beach and Nepeague bay is a salt marsh, on which much salt hay is cut and cured annually.†

Much of the surface between Sag-Harbor and Easthampton, and thence towards Southampton, is, in its natural state, a loose and drifting sand; and unless restrained by cultivation or other artificial causes, would cover the adjacent fertile fields. Many localities are known to the old inhabitants, that were once fruitful fields, but are now barren drift sands; and others that were covered with such sands are now fertile fields, the sand having drifted off, leaving the heavy loamy soil to form the surface.

One place was observed near Wainscott, where there were deep and broad wheel tracks on the loam, where the sand had recently drifted off. An old man present remembered, that when a boy, a whale had been dragged across that place, partly supported by wheels. The soil had been covered up by the drift sand; and again, after an interval of many years, had been uncovered by the operation of the same cause.

Between Canoe place and Riverhead, the country is a deep drifting sand, except where the wind cannot act upon it, in consequence of the growth of bushes, dwarf pines, and small

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* Dr. James G. Graham. Medical Repository, N. Y. 1801, Vol. 4, pp. 213, 214.

† Those persons visiting Montauk point in the summer season, (the time when that place is most visited,) should be well prepared to withstand the assaults of the blood thirsty little insect called the *musquito*, which swarms on Nepeague beach in countless multitudes. My horse's sides were *blackened* with them; and although provided with thick gloves and *musquito veils*, myself and lady were much annoyed. I never saw them *more* numerous on the Fox River marshes of Wisconsin, or on the waters of the Mississippi in Louisiana, or of the Red river in Louisiana, Texas, and the Indian country. The musquito veil, to afford the greatest protection, should be of thin gauze, sewed up like a bag, except that one seam is left partly unsewed, with a gathering string at the bottom. It is drawn over the hat or bonnet, the open part closes over the shoulders, and by means of the string, it is tied close around the waist. The breathing and sight are left unobstructed, while the access of these annoying little animals is cut off.

oaks. The same is true of an extensive region extending from Canoe place west, through the central parts of Southampton, Brookhaven, the northern parts of Islip, across Huntington, where it communicates with the great south plain of Long island. This sandy region belongs to the quaternary; but as it is so much modified in its characters by alluvial causes, it is here mentioned. There are many local examples of such drifting sands belonging to the quaternary, and some even to the tertiary. Much of the extensive sand region above mentioned, between Patchogue and Riverhead and Canoe place, is more or less composed of hillocks of sand, or dunes like those on the coast; only there are a few pebbles, of the size of bullets, found in some places. The country is almost entirely in its wild native state, and no house or hut is to be seen for miles in many parts of this tract. In this sandy region, and in its extension farther west, where it is also covered by a stinted growth of scragged oaks, pines and bushes, the deer still lives wild, and is occasionally hunted by sportsmen.

On Lloyd's neck at East-Fort, on the summit and back of the high cliff of tertiary, is a space of many acres of drifting sands. By the sides of the fences and other obstacles, it is piled up in every fantastic shape, like snow drifts. In some places it has drifted off so as to expose the underlying loam.

On the north branch of Long island, the same character of drifting sands may be seen in patches more or less extensive, between Riverhead and Mattituck, and between Riverhead and Middle island.

Salt Marshes.

The principal marshes have been mentioned.* The smaller ones are too numerous to enumerate. Some few that have not been spoken of, and that are experiencing marked changes, will be mentioned. They are mostly indicated on the map of Long island (vide Plate I.).

An extensive marsh is in process of formation in Musquito cove.

The salt marshes near the head of Little neck bay occupy several hundred acres.

The east and southeast parts of Oak neck are gaining continual accessions by alluvial action; the east by beach sand, and the southeast by marsh mud, marsh and marine plants and marine shells. The latter are washed up in large quantities by the waves, intermingled with sand.

Beaches, Spits, and Bars.

A long sand-spit extends out from the west side of Coldspring harbor, and another from the east side about half a mile below the village, so as to nearly close the opening. Another extends from the beach between Lloyd's neck and West neck, to the second, third and fourth brick-kilns. A marsh extends from the first or northernmost brick-kiln to the head of Lloyd's harbor. The isthmus connecting Lloyd's neck and West neck is a sand beach, entirely alluvial.

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* Vide p. 18 of this volume.

On the north side of Lloyd's neck, a sand-spit extends nearly parallel to the original beach, to near the mouth of the west inlet, and there gives a passage to the main or east inlet, draining the large marsh between the beach and the clay and sand hills of the neck. The alluvial lands are here rapidly increasing in area, from the drifting up of shells, sea-weed, and the sand and gravel swept along by the strong tidal currents.

A small sand-spit extends nearly across the harbor, from the northwest part of East neck.

Natural Ice-houses.

In Phillipstown, Putnam county, in a transverse valley crossing westward from the Fishkill and Coldspring valley, in a deep gorge of the mountains called Hell Hollow, ice frequently lies until August, and sometimes through the year. In some parts of this gorge, the sun is said never to shine by its direct rays.

Another locality is in Stony clove, a deep gorge in the Catskill mountains, northward from Woodstock in Hunter, Greene county. Another in Deep hollow in Lexington, Greene county, in a deep gorge in the mountains, between the head waters of the West kill of Schoharie creek, and the Bush kill of the Esopus creek. Ice is said to remain in these valleys till late in the summer. Another or others have been described in Pownal, Vermont, or in Petersburgh, Rensselaer county, New-York, very near the State line.*

Subterranean Streams.

"At a short distance from the Canaan line in Columbia county, a small stream of water sinks in the ground near the lime rock, and does not appear again for about one fourth of a mile, when it comes to the surface on the land of Mr. Lord."† For other examples of subterranean streams, see pages 109 – 113 of this volume.

Bursting of a Pond.

Many years since, a pond, skirted with marsh containing trees, was situated near the edge of the cliff near Swezey's landing, Suffolk county, Long island. Mr. Skidmore stated, that one of his brothers, when young, was playing with another lad in this pond, when the water in it was higher than usual. The water burst its barrier, and flowed with the sand of the cliff so suddenly into the Sound, as to uproot and bear away the *trees*, even, in the marsh around it. The boys were hurled down the cliff with the descending torrent, with trees, mud and sand, into Long Island sound; and the brother of Mr. S. was so much bruised, that he died in consequence of his injuries.†

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* Vide American Journal of Science, Vol. 1, p. 340; Vol. 4, pp. 331, 332; Vol. 5, p. 398.

† Briggs. Geological Notes on New-York Survey.

Shell Banks of the Coast of New-York.

These are very numerous on the coast of New-York, and of all New-England. The reasons have already been given why they are considered as alluvial, and caused by the labor of man, mostly by the aborigines of the country (see pages 21 and 175 of this volume). Some of the more prominent localities only will be mentioned. From some of them, thousands of cart-loads of the shells have been removed, and spread over the lands, to increase their productiveness. They decay very slowly, and act to afford lime for a long time to the soil and to vegetation.

Several localities were observed between Canoe place and Sebonac neck, Cow neck and Farrington's neck, near the shore, and generally near the heads of the small bays and on their sides; sometimes bare, and sometimes covered by one or two feet of drift sand. Another on the west side of Great Hog neck, two miles from Sag-Harbor. Another near Old Man's harbor. Large quantities have been removed from these beds for manure.

Alluvial Sandstone and Conglomerate.

Some localities of these have been mentioned, (see pages 122 and 160 of this volume.)

Alluvial sandstone was observed in many places along the north coast of Long island, formed by the chalybeate springs depositing iron as a cement between and around the grains of sand and gravel. Many large blocks, that had tumbled from the cliffs, were lying on the shore. They may be seen one quarter of a mile east of Hudson's point, and half a mile and one mile east of the same. These distances may not be strictly accurate; they were estimated by the eye. At the last mentioned locality, a chalybeate spring flows from the ravine, and has caused the yellow and reddish color of the sands, and the aggregation of sand into rock.

Agaric Mineral.

This is said to occur near Catskill. The exact locality is not specified.* I did not find it.

Bog Ore.

Many of the springs that flow from the north side of Shawango neck, west of Montauk point, Long island, are highly impregnated with iron, and some bog ore is deposited in the pond-holes and marshes.

In Stillwater, Saratoga county, bog ore is found on the land of Mr. David Montgomery. The locality is four and a half miles north of Maltaville, and three miles west of Stillwater. It was

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* Robinson's Catalogue of American Minerals, p. 120; and Cleaveland's Mineralogy, p. 170.

examined by Mr. T. Seymour.* The owner, Mr. Montgomery, informed him that the ore was about one and a half feet below the surface, over about one acre of ground, and four feet thick.

Chalybeate Springs.

A chalybeate spring (supposed to be), called the *Yellow spring*, is said to exist on Judge Osborn's farm, one mile south of his house, on Farrington's neck, Southampton, Long island. The water sinks in the sand a short distance from the spring.

Water colored by iron, was seen by the mill two and a half or three miles from Sag-Harbor, and a mile from the south end of Farrington's neck. This fact has been observed generally at all the mill-dams of Long island, and other parts of eastern New-York, where sand and gravel have been used to make the dams. The water oozing slowly through those materials, has carbonic acid enough in solution to dissolve some of the oxide of iron in the sand and gravel; and this is deposited again in the still stagnant and evaporating water in the pools below the dams, during the droughts of summer. These appearances are sometimes also due to infusoria.

At Horton's point, Southold, Long island, is a small chalybeate spring, perhaps too small to be of importance.

Another, more copious, was seen one mile east of Hudson's point, in Riverhead township, Long island.

Several were seen on the north side of Shawango neck, west of Montauk point, Easthampton, Long island. Some flow from the low cliffs along the shore; others around the pond-holes and hollows in the hilly region.

Another was seen in Livingston, Columbia county, a few rods west of the road, between the Blue store and Johnstown, in a small ravine in the quaternary formation. There was an abundant flow of water.

Another was examined near the mill in the yard of Mr. ———, in North-Salem, Westchester county, two miles east of the Academy. This spring fills a half inch tube with a steady flow of water. It was examined by Prof. Cassels. It is near the celebrated block of granite, supported on small colums of primary granular limestone. (Vide Pl. 37, fig. 4.) †

A great number of springs of fresh water flow from the base of the hills at the head of Little Cow harbor, in Suffolk county. Two springs at this place are slightly chalybeate.‡

Among the numerous springs that supply the mill near Elderkin's, in Setauket, are one or two chalybeate springs.‡

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* Mr. Seymour was one of the junior assistants on the Geological Survey. He has collected many interesting facts, and copied many of the drawings and sections for this volume. He is now a cadet in the United States Military Academy, and fitting himself for his country's service.

† American Journal of Science, Vol. 2, p. 200.

‡ Briggs. Notes on Geological Survey of New-York.

INFUSORIA.

At the time the article on Alluvial Deposits was printed, the third part of Prof. Bailey's Paper on American Bacillaria was not completed. It necessarily comes into the supplement, and is a part necessary to the description of the Infusoria of the First district of New-York. It is as follows :*

The section Echinellea contains those Bacillaria which are *fixed*, that is, attached either by their extremities, or by a pedicel, to other bodies. They are all siliceous.

The section Lacernata includes those which have a double covering. They consist of groups of siliceous individuals, surrounded by a common gelatinous mass, or enveloped by a membranous tube.

As many species of each of these sections are often found spontaneously or accidentally separated from their pedicels or tubes, there is great chance of mistaking them for species of Naviculacea.

Section III. ECHINELLEA.

Isthmia. *Fixed by one end; carapace or lorica siliceous, simple, broader than long, catenate by imperfect spontaneous division; individuals making various angles with each other, and connected by a narrow isthmus or neck-like process.*

Two species of this genus have been detected, viz. *I. enervis*, and *I. obliquata*. Neither of these have, to my knowledge, yet been detected in the United States; but as the latter is a pelagic species which has been found in places so different and distant from each other as Iceland, England, the Canary islands, Cape of Good Hope, &c., there can be little doubt that it will yet be found growing on some of our marine Algæ. The first specimen which I ever saw, I detected on a dry specimen of Odonthalia dentata from Iceland. I have since received fine English specimens from E. J. Quekett, Esq. of London. Few microscopic objects exceed in beauty these little gems of the ocean. I have proved that their carapace is siliceous, by the proper chemical tests. A good idea of the general form of this genus may be got from Plate 4, fig. 153, of Pritchard's Infusoria.

Synedra. *Carapace simple, siliceous; fixed when young by one extremity, when older often free, longer than broad; foot either wanting or rudimentary; form elongated or prismatic.*

Synedra ——— ? (Pl. 42, fig. 1.) Frustules long, slender, linear, adhering laterally into plates which are supported by a short fleshy pedicel, and terminated by a fleshy mass.

The species whose usual appearance is shown in Pl. 42, fig. 1, occurs in vast quantities on various algæ in the Hudson river at West-Point. It usually completely envelopes the plants to which it is attached, giving them a covering of bristling crystal-like particles, through

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* Prof. Bailey's Part 3 of American Bacillaria, from the American Journal of Science, Vol, 43, p. 3 to 13.

which it is often difficult to see any portion of the supporting plant. When the algæ on which it grows are dried, they often have a greenish grey hue, from the presence of this parasite.

It presents considerable resemblance to S. gailloni, Ehr. (Diatoma crystallinum, Ag.) and has, like that, minute striæ on the edges; but I have seen no allusion made in the descriptions of that species, to the fleshy projection which is so conspicuous in our species.

A person who sees how abundant this species is in the recent state, will no longer wonder that in the lapse of years masses of infusorial shells should accumulate so as to form extensive strata.

Synedra ——? (Pl. 42, fig. 2.) Frustules linear, strait, striate, truncate on the lateral side; ventral sides with a neck-like contraction near each end; ends rounded.

This species is very abundant in fresh water near West-Point, often covering aquatic plants with a glittering envelope of crystal-like frustules. The individuals are perfectly linear, with truncate ends. When seen laterally, they show near their extremities a slight contraction, which forms a neck supporting the round of knob-like terminations. Minute striæ may be seen as represented in the figure.

This species presents many points of resemblance both to Synedra ulna and Fragillaria rhabdosoma of Ehrenberg, but I cannot identify it positively with either.

PODOSPHENIA. *Carapace simple, siliceous, cuneiform; fixed when young by one end, afterwards often free; longer than broad; pedicel small, hemispherical, or wanting.*

In Pl. 42, fig. 3, is represented a species which agrees with the above generic characters, and which I therefore place here, although it is a fluviatile production, while all of Ehrenberg's species are marine. It invests stones, etc. in small streams near West-Point with a yellowish green covering, which appears like a mere stain; but which, when scraped off with a knife, is seen to be composed of excessively minute frustules resembling those of Gomphonema, but which have no perceptible pedicel.

GOMPHONEMA. *Carapace simple, siliceous, cuneiform; fixed upon a distinct filiform branching pedicel; dichotomous by spontaneous division.*

Gomphonema minutissimum. (Pl. 42, fig. 4.) Smooth? corpuscles cuneiform, curved, clavate, $\frac{1}{144}$ to $\frac{1}{72}$ line.

A minute species agreeing closely with Kützing's figure of G. minutissimum (see Linnea, 1833, fig. 43), occurs abundantly on various aquatic plants in the Hudson river at West-Point. It varies much in size; fig. 4, *a*, shows the largest individuals, and fig. 4, *b*, the smaller ones.

Gomphonema ——. (Pl. 42, fig. 5, *a*, *b*.) This large and beautiful species appears to be related to G. dichotomum and to G. geminatum, but I am unable to satisfy myself of its identity with either. I found it in vast quantities at the Island of Mackinaw, Straits of Michillimacinac, on a large cedar tree which was sunk in water ten or fifteen feet deep, and which was literally covered with large waving bunches of a yellowish white color, composed of the dichotomous filaments of this species, glittering with crystal-like particles.

The individuals are striate, with one side cuneate, and showing at the broad end two interior arcuate folds; the other side is elongated, obovate or clavate, with a central circular spot and longitudinal smooth portion. The pedicel is repeatedly dichotomous.

Gomphonema acuminatum? (Pl. 42, fig. 6.) Striate; corpuscles elongated; wedgeform, end swollen and pointed, contracted on the side.

The small species (fig. 6) agrees pretty well with the above characters. It is common in ponds near West-Point. I have also seen it in several American specimens of fossil infusoria.

Gomphonema ———. (Pl. 42, fig. 7.) Frustules smooth, geminate or in fan-shaped groups; one side elongated, wedge-shaped, truncate; the other side obovate; pedicel repeatedly dichotomous. Marine.

I have examined this species only in a dry state, having first noticed it on a glass slide on which I had preserved some specimens of Echinella flabellata from Stonington, Conn. The figure is drawn from the dry specimens.

ECHINELLA, Ehr. *Carapace simple, siliceous; fixed at one extremity to a pedicel; wedgeform, longer than broad, fan-shaped or verticillate by spontaneous division.*

Echinella flabellata. (Pl. 42, fig. 8.) Smooth; corpuscles linear, cuneiform, truncate, slightly three-toothed, striæ longitudinal, $\frac{1}{16}$ line without the pedicel. *Licmophora flabellata*, Ag. (Greville in Hooker's English Flora, Vol. 5, p. 408.)

This beautiful marine production presents, in its fan-shaped groups of crystal-like corpuscles, an exceedingly elegant appearance. The fans are supported by long flexible clavate pedicels, which are grouped together in large bunches covering filamentous marine algæ and zoophytes.

I found it quite abundant at Stonington (Conn.), in July. It is said to occur also in Scotland, Venice, and at the Cape of Good Hope.

Echinella ———. (Pl. 42, fig. 9.) Corpuscles smooth? lanceolate, truncate; pedicel short, broadly clavate, often nearly circular, supporting the radiating closely aggregated corpuscles.

I detected this very elegant species about a year since in the Hudson river near West-Point, where it grows upon Potamogeton, Enteromorpha, etc. It agrees in many respects with E. fulgens, Grev.; but that is described as being striate, a character which I have not perceived on our species.

COCCONEMA. *Carapace simple, bivalve or multivalve, siliceous; fixed by one end, pediculate, longer than broad; pedicel in the direction of the axis of the body.* (*Pedicellate Naviculæ.*)

When separated from their footstalks, there is no good character to distinguish them from Navicula, but the unsymmetrical boat-shaped frustules of Cocconema will *generally* serve to identify them.

Cocconema ———. (Pl. 42, fig. 10.) Carapace lanceolate, ends obtuse, pedicels repeatedly dichotomous, secondary branches articulated to the primary ones. Striæ were not perceived.

Abundant in the Hudson river at West-Point. It appears to be allied to C. lanceolatum of Agardh.

Cocconema ———. (Pl. 42, fig. 11, *a*, *b*.) These figures represent two positions of a species of Cocconema which is very common in the living state near West-Point, and which also abounds as a fossil. In the living state, I have but rarely seen it attached to a pedicel. It is generally free, and moves about spontaneously like a Navicula.

I once, on a cold day in October, noticed vast collections of this species which were enveloped in a mucous covering, and which formed large cloud-like masses several inches in extent, investing aquatic plants, stones, etc. Each of these masses was crowded with millions of the siliceous shells of this species.

Ehrenberg mentions C. asperum as a new species detected by him among the fossils from West-Point. I am ignorant of its distinguishing features.

ACHNANTHES. *Carapace simple, bivalve or multivalve, siliceous, prismatic, longer than broad; fixed by one end, pedicellate; pedicel oblique, ventral, always simple, opening in the middle of the body. Groups, resulting from increase by spontaneous longitudinal division, resembling chains, little banners, plates or ribbons.*

Achnanthes brevipes. (Pl. 42, fig. 12.) Corpuscles striate, curved in the middle, ends rounded on the dorsal and ventral sides; pedicel thick, shorter than the body.

I first noticed this species on filaments of Conferva fracta from Providence cove (R. I.), and have since found it abundant on marine algæ from Stonington (Conn.). Small specimens, differing I believe in no essential character, are also very abundant on aquatic plants in the Hudson river at West-Point.

The Achnanthes longipes of authors may be a distinct species, but the distinction "pedicel longer than the body," appears to me to be founded on a character liable to much variation. I saw specimens at Stonington having pedicels much longer than the body, yet they appeared to me to agree with E. brevipes in every other respect.

STRIATELLA. *Carapace simple, siliceous; fixed by one end, longer than broad, or nearly square, obliquely pediculate in form of little flags; corpuscles without openings in the middle, often forming zigzag chains by spontaneous divisions.* (*Stipitate Bacillariæ.*)

Striatella arcuata. (Pl. 42, fig. 13.) Carapace lamellar, nearly square, with three to seven longitudinal internal lines, transversely striate; polypidoms (flags) in form of ribbons, often curved; nine striæ in $\frac{1}{100}$ line. *Diatoma unipunctatum*, Agardh, Greville, &c.

This species occurs in vast quantities on filiform marine algæ at Stonington (Conn.). It covers the plants in such profusion as to make them glitter in the sunbeams as if covered with crystals. The recent frustules are not flat, but slightly convex, and are usually marked with an internal nearly circular spot, which in my specimens was yellow, not rose-colored as usually described. Considerable variation in the width of the frustules occurs even in the same ribbon. Each plate is transversely striate, the alternate lines not quite reaching to the edge. I saw numerous specimens supported by long pedicels.

Section IV. LACERNATA.

Frustulia, *Ehr. Envelope double; carapace siliceous; mantle gelatinous; amorphous; corpuscles scattered or in groups.*

I have seen no American species of this genus.*

Syncyclia. *Envelope double; exterior mantle gelatinous; carapace siliceous, navicula-shaped; forming by spontaneous division, circular groups surrounded by gelatine.* (See Pritchard's Infusoria, Plate 4, p. 206.)

No American species has yet been detected.

Naunema. *Envelope double; carapace navicula-shaped, siliceous; mantle gelatinous, exterior tubular; tubes filiform, separate, branching, confervoid, resulting from perfect division of the carapace, and imperfect division of the mantle.*

In this genus, corpuscles which cannot be distinguished from those of Navicula are assembled together in vast numbers, in flexible membranous tubes, within which they may often be seen to move freely. They doubtless often leave these tubes, and then appear like species of Navicula.

I have noticed several American species, but I am unable to decide whether they are identical with any hitherto described, as I have had very little opportunity to study our species in a living state, and have no foreign specimens or figures to compare them with. I shall therefore content myself with merely giving the forms of the frustules found in each species, and such additional particulars as seem most interesting.

Naunema ———. (Pl. 42, fig. 14.) The figure represents corpuscles from a branching species found on the shores of Staten island, N. Y. The tubes are whitish, containing long rows of corpuscles, strung end to end, each of which contains two round globules looking like air-bubbles. No trace of striæ.

Naunema ———. (Pl. 42, fig. 15.) This figure shows the form of corpuscles which filled short robust unbranched filaments, which were exceedingly lubricous. Bunches of filaments about half an inch in length, were found in great abundance on Zostera, &c. at Stonington, Conn.

Naunema ———. (Pl. 42, fig. 16.) This figure shows the outline of dried corpuscles from a specimen obtained at Stonington, Conn., where it is very common. Its filaments are branched, and form larger and longer bunches than the preceding, with which it occurs.

Naunema ———. (Pl 42, fig. 17.) This is from specimens found in immense quantities in the Hudson river, at West-Point. The masses have not the green color of the two preceding species, but present a rich brown color. The frustules are in all respects like those of Navicula, and I have often seen them move spontaneously in their tubes, some going one way and others another.

In Pl. 42, fig. 17, *a*, is shown the outline of much longer frustules, found in tubes similar to those just mentioned.

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* My opportunity to study the marine Bacillaria has been very slight. I presume, therefore, that many marine forms not noiced by me during the two days which I spent at Stonington will yet be detected, and among them will probably be species of Frustulia, Syncyclia and Schizonema.

GLŒONEMA. *Envelope double; carapace siliceous; mantle tubular; tubes simple, often branched; corpuscles curved, resembling* COCCONEMA *in a tube.*

Mr. Berkely has recently published (Ann. and Mag. Nat. Hist. Vol. 7, p. 449) some interesting observations, by which he appears to have proved that the only species of this genus, the singular *G. paradoxum*, consists merely of rows of ova of some aquatic insect. He watched their development into larvæ. I have not seen American specimens.

SCHIZONEMA. *Envelope double; carapace siliceous; mantle tubular; tubes united in bundles, split in some places so as to appear branched; corpuscles like those of* NAVICULA.

No American species has yet been detected by me.

It was my intention when I commenced the above sketch, to give, in connection with it, an account of all the American localities of fossil infusoria, but further reflection has convinced me that this labor is unnecessary. All our fluviatile deposits of fossil infusoria contain nearly the same species, and all these species are now living. From the great range which the living species have been shown to have in our country, there is great probability that all the siliceous ones may be detected, if carefully sought for in any of the specimens of fresh-water infusorial deposits. As for the localities at which these fossil infusoria occur, it does not appear that a particular enumeration is necessary. The living animals inhabit in great quantities almost every place where water remains several months in the year; their indestructible shells are therefore to be found in greater or less quantity in the sedimentary deposits of all our bogs, ponds and slow streams. These deposits are most remarkable beneath peat bogs, where they constitute strata many feet in thickness, and of great extent, often composed entirely of the siliceous carapaces of animals so minute that millions of them exist in a cubic inch. The "siliceous marl" which they form, is often so white and light as to be mistaken for magnesia, and Dr. Jackson states that it has actually been sold as such to apothecaries, who were much surprised when informed by him that not a particle of magnesia was present.

Among the vast number of fluviatile localities now known, I think it necessary to allude only to the following, viz: West-Point, from which specimens have been examined by Ehrenberg, whose list of the species is given in the American Journal of Science, Vol. 39, p. 193; Blue Hill pond, and various other localities in Maine, discovered by Dr. Jackson; Manchester, Spencer, Wrentham, Bridgewater, Andover, &c. in Massachusetts, discovered by Prof. Hitchcock; and Smithfield and other places in Rhode-Island, discovered by Owen Mason, Esq. The largest and most conspicuous species from all these localities are Navicula viridis, Pl. 22, fig. 16, Navicula ——? Pl. 22, fig. 23, Cocconema ——, Pl. 41, Eunotia arcus, Pl. 22, fig. 26. With these occur various smaller species, and numerous siliceous spiculæ of fresh-water sponge, Pl. 42, fig. 18, *a* to *d*, and other siliceous bodies of organic origin, such as the Amphidiscus rotula of Ehrenberg, Pl. 42, fig. 20, and others whose nature is unknown, but which I suspect to be of vegetable origin, perhaps prickles of aquatic grasses. (See Pl. 42, figs. 21, 22 and 23.)

The most interesting American deposit of fossil infusoria, is the "infusorial stratum" discovered by Prof. W. B. Rogers, of the University of Virginia. It is peculiarly interesting

from its vast extent, the beauty of its species, and from its belonging to the marine tertiary formations. All other American fossil infusoria yet discovered are of fluviatile origin, and of the most recent date.

I have already pointed out the striking correspondence between the fossils of the infusorial stratum of Virginia and those of Oran in Africa. This is shown by the occurrence of vast quantities of various species of Coscinodiscus and Actinocyclus, with Gaillonella sulcata? etc. Believing that it will be of great interest to geologists both at home and abroad to trace out this correspondence of the fossils of regions so far distant, and of beds which are at present referred to different epochs,* I have added to my plate third, a number of figures of siliceous bodies not before described, found in the infusorial stratum of Virginia. The following is a brief account of these bodies.

In Pl. 42, fig. 24, *a*, *b*, *c*, are shown different views of small siliceous bodies, which are quite frequent in the infusorial deposits both of Richmond and Rappahannock cliffs. They consist of a concave rhomboidal body, formed of open work, or with large perforations, and having at the extremities projecting spines. These belong to the genus Dictyocha of Ehrenberg, several species of which occur at Oran, Caltasinetta, &c.†

Pl. 42, fig. 25, shows a siliceous ring with projecting spines; it is possibly a fragment of the preceding.

Pl. 42, fig. 26, shows a circular ring, connected with a concentric hexagon by six rays proceeding from the angles of the hexagon. The spaces within the hexagon and below the rays are perforations. It is another species of Dictyocha. It occurs occasionally among fossil infusoria from Richmond and Rappahannock cliffs.

Pl. 42, fig. 27, shows a curious fragment, apparently siliceous, having a campanulate form with a projection at the apex, and pierced with large holes. Fig. 28 shows an ovoid body perforated by similar holes. Of the nature of these curious fossils, I am entirely ignorant. They occur with the preceding.

Pl. 42, fig. 29, shows a triangular binary siliceous body, resembling some of the fluviatile species Euastrum. The surface is covered with minute dots, some of which form lines leading from the centre to the angles. Perhaps this belongs to Ehrenberg's genus Triceratium, of which species occur fossil at Oran, and living in Cuxhaven.

In Pl. 42, figs. 30 to 35 show siliceous bodies which are quite abundant with the preceding forms, and which I suspect are spiculæ of marine sponges. Many of them show a central perforation, like that in the spiculæ of Spongilla.‡

Other interesting forms occur in the infusorial strata of Virginia, but the limits of this paper will not allow me to present any more of them at present. I have transmitted specimens from

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* Ehrenberg refers the infusorial conglomerates of Oran, &c. to the *chalk* formation; but Rozet considered them as *tertiary* deposits, and Prof. Rogers states that the beds discovered by him separate the *miocene* from the *eocene* tertiary beds of Virginia.

† Since the above was in type, I have seen Ehrenberg's figures of several species of Dictyocha in the Berlin Transactions, and find them to agree with the bodies above referred to.

‡ I have reason to believe that similar siliceous spiculæ occur in vast quantities in the external rays of some species of Actinia.

Richmond to Ehrenberg, and he will doubtless determine to what extent the African and American beds agree in their microscopic fossils. As the infusorial strata of Virginia belong decidedly to the tertiary epoch, and yet appear to agree remarkably with what Ehrenberg considers as chalk marl from Oran, a revision of the evidence upon which the siliceous infusorial conglomerates of Africa and the south of Europe were referred to the cretaceous group, appears necessary. Should the true age of either the American or African deposits be determined by means of the fossil infusoria, it will be an additional instance of the importance of this branch of microscopic palæontology. It has been well remarked that the microscope is now as important an instrument for the geologist as the hammer; and indeed the results obtained by microscopic observation of coal, fossil wood, teeth, polythalamia, and infusoria, prove the truth of this remark. The question *cui bono?* to what useful end are your pursuits? can now be triumphantly answered by the lover of microscopic research; but happily, to use the words of the Hon. W. H. Harvey,* the class who now ask this question to naturalists "is neither so numerous nor respectable as it was two years ago; it is becoming every day less so, and will soon be confined to the ignorant and the sensual." In the language of another distinguished philosopher,† "the time is past when the utility or dignity of such pursuits can be affected by a sneer at the littleness of their objects, as they seem little in the eyes of the indifferent and the ignorant. Every thing is great or small only by comparison; the telescope teaches us that the world is but an atom, and none know better than microscopical observers that every atom is a world."‡

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* Manual of British Algæ, by the Hon. William Henry Harvey.

† Richard Owen, Esq. Address before the Microscopic Society of London, 1841.

‡ American Journal of Science, Vol. 43.

CHAPTER III.

TERTIARY DEPOSITS.

At the time of the tabular arrangement of the order of the different formations (see page 2 of this volume), I had not investigated and embodied all the facts affording evidence on the proper place in the geological series, for the Long island formations, and it was mentioned that the order of arrangement would be,

1. Quaternary system;
2. Tertiary system;
3. Trappean system;
4. Red sandstone system, etc.

The Quaternary system, and its divisions, have been considered. The next in order is the Tertiary; but from the facts that will be adduced, it will be shown that we have no data for describing with *certainty* any tertiary formations in the First Geological District, although they may exist on Long, Staten and other islands. The equivalency of most of the strata of Long island, below the drift epoch, to the marl deposits, and particularly to the subjacent sands, clays, etc. of New-Jersey, is considered as established beyond all reasonable doubt, by the identity of some of the strata and their contents, notwithstanding some striking variations in the mineral composition of some of them.

I shall therefore propose a modification of the arrangement of the subject as laid down on page 2 of this volume, and that the third general division shall embrace, first, the Long island strata of sand, clay, etc. that are exposed below the drift; secondly, the trappean rocks; and thirdly, the red sandstone, thus:

Upper Secondary System.
1. Long-island division.
2. Trappean division.
3. Red Sandstone division.

It was supposed that the Long island strata belonged to the tertiary epoch, and it was intended to discuss these deposits under that head, although there was not evidence sufficient to make it at all *certain* that they belonged to that period. The strata that belong to the tertiary epoch, if they exist on Long island, as they probably do, will, in this report, be em-

braced in the description of the LONG-ISLAND DIVISION. I would adopt the names by which the equivalent strata in New-Jersey, Delaware and Virginia, have been described; but that the names would be less descriptive of the composition and characters of the strata, than the LONG-ISLAND DIVISION will be for other portions of the country, where equivalent formations occur. Again, should subsequent investigations prove that I have erred in assigning the lower formations of clay, sand, etc., exposed on Long island, to the upper division of the secondary deposits, and as equivalent in age to the sands, clays and marls of the cretaceous and lower green marls, and lower clays of New-Jersey, the term *Long-island division* will *still be appropriate*, and the descriptions true.

CHAPTER IV.

UPPER SECONDARY SYSTEM.

This system contains three divisions, viz.

1. Long-island division.
2. Trappean division.
3. Red Sandstone division.

I. LONG-ISLAND DIVISION.

The Long-island division of deposits is composed of strata of sand, clay, gravel and pebbles. The sands are white, yellow, red, and variously tinged. The clays are blue, white, mottled of white, red and yellow; some are brown, greenish, and pyritous. The pebble and gravel beds are composed of fragments of rocks that exist in place, within a distance of fifty or one hundred miles. Fossil shells are said to have been found in many places. Lignite has been found in numerous places, both by myself and others.

The geological position of this formation is between the drift deposits and the red sandstone formation of New-Jersey and Rockland county; for its position beneath the drift can be seen in a great number of places, and red sandstone pebbles and red sand from the destruction of this sandstone may be plainly distinguished in many localities. The reasons for believing that the principal mass of this formation is older than the tertiary, will be seen in tracing the equivalency of these beds to those of New-Jersey, Maryland, Delaware and Virginia, where it is considered as established that the corresponding strata belong to the upper secondary of the epoch of the cretaceous and greensand formations.

Location and Extent.

The tertiary deposits of the First Geological District have been found in New-York only on the island of New-York, Staten island, Long island, and Gardner's, Plum, Shelter and Governor's and Bedlow's islands; but it undoubtedly exists beneath the drift deposits of most of the islands in Long island sound, as Gull islands, Fisher's island, Hart's island, Brothers, City island, Barn islands and Riker's island. It is usually covered by a mantle of the drift,

or of the quaternary or alluvial deposits. It is supposed to underlie the whole of Long island, except that part near Hurlgate, at the west-northwest extremity of the island, where the drift is superimposed directly on the primary rocks.

Mineral Composition and Texture.

The *general* character of the composition and texture has already been alluded to; the *local* characters will be made known in discussing the different localities that have been examined, and the sections obtained from various sources.

The great storm and gale of the eleventh and twelfth of October, 1836, in consequence of the encroachments of the sea on the land, exposed beautiful sections of the strata on the coast, and gave an opportunity, not often presented, of examining *fresh* sections along an extensive line of coast.* The remainder of the autumn of that year was devoted to meandering the coast, and ascertaining the order of superposition of the different masses on Long island.

At Oysterpond point, the storm caused a breach across the point about forty rods from its eastern extremity, washed off the *drift* deposits (that form some of the surface in that vicinity) except some large blocks, and exposed the underlying *red clay*. This could only be seen at ebb tide, and was in a few days covered by sand and gravel washed over it by the surf.

Between Brown's point and Petty's bight, about three to three and a half miles west of Oysterpond point, the sections figured on Plate 4, figs. 4, 5, 6, 7, 8, were observed.

Figures 4 and 5 of Plate 4 represent the brown and reddish slaty clays (which are left blank on the figures) penetrating upwards, and deranging the position of the superincumbent sand; while the clay and pebble beds above, and which also belong to the same geological *epoch*, rest *unconformably* upon them. The lines are not drawn to illustrate the contortions of the brown and red clays, for it would require an artist to give all the beautiful and complicated curves that a fresh section exposed to view. The contortions of these two sections were probably produced by the lateral thrust of slides, though no traces of slides were there observed except these contorted strata; and there is no other cause to which I can ascribe the effect, where the *underlying strata are undisturbed* as was the case in fig. 5.

Fig. 7 of Plate 4, shows alternations of arched strata of sand and clay, covered unconformably by a stratum of clay, which rests horizontally on the denuded edges of the arched strata. Four distinct periods are here indicated:

1. The deposition of the alternating strata.
2. Their elevation and denudation.
3. The deposition of the clay bed unconformably.
4. The deposition of coarse materials and boulders.

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* In a short time after such sections are made, the sand and gravel beds crumble down so as to conceal the strata, or the clay beds slide; so that the observer is so very liable to wrong conclusions from so many sources of error, that it is almost impossible to avoid them all.

Fig. 8 shows the highly inclined strata of sand and clay that must have been deposited in laminæ nearly horizontal; and one of the clay beds shows the wrinkling or folding upon itself, in consequence of its own weight, since it has been placed in its present position.

Fig. 15, Plate 4, shows a small part of a disturbed stratification of the clay and sand beds, with unconformable strata of later date superimposed. This locality is twenty or thirty rods west of Brown's point. Fig. 6, in Petty's bight, shows the same. Fig. 9 shows slides, from recent causes, of the same strata, but conformable, about one and a half miles west of Brown's point, Long island.

It will be observed in all these, that the drift deposits occupy the same position above the strata of the Long-island division. This, and the enormous size of some of the boulders and blocks, has already been alluded to in the article on the Drift deposits.*

Fig. 10 of Plate 4, shows an arching of the strata, the crown of the arch being covered by a slide of the sand and gravel beds from the top of the bank. This locality is on the west side of West neck in Huntington, Long island, three quarters of a mile east-southeast of the brick-kiln on the shore of Coldspring harbor. The strata there dip to the north, and to the south. The sand is divided into regular layers by fine partings of clay, but most distinctly on the south end or right-hand end of the section; and also by sand cemented into a soft crumbly mass, by small particles of a whitish material, that may be kaolin, derived from decomposed feldspar,† or minutely comminuted shells.‡ The sand of these beds is very white, with an occasional stripe of a slight tinge of yellow. Some of the strata of sand are composed of very minute grains. A material may here, and at many of the tertiary sand beds, be procured, such as that used by lithographers in rubbing down their stones. The material used heretofore for that purpose, has been imported from France.

The clay beds at this locality are an impure potter's clay; some of it pretty white; some dark coloured, brownish; and some variegated and reddish.

Fig. 12 of Plate 4, shows beds of sand of this formation, with their water lines or laminæ of deposition, as well as their stratification, and traversed by a fault. This locality is fifty or sixty rods north of the preceding, on the east shore of Coldspring harbor.

Fig. 14 of Plate 4, shows the drift deposits overlying the very irregular surface of the sands beneath. The figure also shows the laminæ of deposition, as distinguished from the stratification. The upper part of the figure, representing the drift deposits, does not convey the proper idea, in consequence of its having been badly copied. It is represented with highly inclined strata, while they should have been nearly horizontal; and at the place where the lower tree is represented, a slide from the top of the bank should also have been represented.

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* Vide page 163 of this volume.

† A material of this kind is very common in the sand and gravel beds of the west end of Long island, and this place was the first where it was observed. It was afterwards seen better characterized, and is probably derived from the same rock as the source of the boulders containing such a material, and described as occurring at Whitestone, at three miles east of Flushing, and on Staten island, &c.

‡ No acid was applied to test the presence of carbonate of lime.

Fig. 13, Plate 3, represents contorted strata of sands and clays, on the north side of a small valley extending east and west, near the other localities that have been mentioned on West neck. The sands and clays are beautifully variegated in some of the beds. I do not know how to explain the position of the strata observed at this place, except some force has bent up and overturned them. A lateral thrust from sliding of the strata *might* have effected it, if the direction of the force was from the right-hand side of the section (the south); but if such were the cause, it must have acted before the excavation of the valley on that side.

The sands and clays on some parts of West neck are of beautifully bright and delicate colors, and arranged in strata, and striped in their laminæ of deposition, so as to present a very pleasing aspect to the eye where fresh sections were exposed. The principal colors of the sands are red, light red, salmon color, buff, light and deep yellow, white, grey and black. The clays are blue, brown, white, grey, bright and mottled red, and bright and mottled yellow.

Some localities have been mentioned, where the strata of West neck dipped north, south, etc. The general dip is to to the east and east-southeast from one degree to thirty, along the west shore. The dip is generally not more than two or three degrees; but the strata are in many places much disturbed, and changed in position from that in which they were originally deposited.

The west side of West neck shows the clay along the shore in very many places. At the brick-yards, of which there are five or six, making 5,000,000 to 6,000,000 of common and stock bricks annually, the clay is at least sixty feet thick, as ascertained by boring. Extensive excavations have been made for clay. The clay beds dip about twenty degrees east. A section at one of the clay pits was as follows:

1. Red clay;
2. Brownish clay;
3. Blue clay;
4. Variegated sand;
5. Red sand.

The variegated and red sands were not seen in the clay pit, but pitched under the clay beds as was observed on the shore. The thickness of the clay beds was not noted, but as near as I can remember, were about twenty feet each, and the two sand beds about the same where they were exposed to view. The white clay was not seen at the brick-yards, but it occurs on West neck in several places, as below the first tide mill; another place still farther down the neck; and also on the north side, west of the pit, and on the road from Huntington to Cold-spring, at the pipe-clay pit. Some of the sand beds are as red as if formed of the sand from the disintegration of the red sandstone of New-Jersey. Some of the white sands of the west shores of West neck and Lloyd's neck are pure enough for the manufacture of flint glass, and others are adapted for lithographic and for fine casting sand.

Mr. Titus' clay pit on West neck is in a bed of blue clay fifteen feet thick, containing crystallized pyrites in nodules. It is overlaid and underlaid by white and light colored clays, and these by sand and gravel beds. The clays are used for coarse pottery.

The west side of Lloyd's neck is high ground, except some small valleys from the east. Yellow ochreous clay overlies light blue clay a few feet above the water, at the base of the cliff on the west shore. Sands, clays, and gravels were seen on the west side of Lloyd's neck, similar to those on West neck. On the northwest side of Lloyd's neck, a fine section of the strata was exposed for half a mile in length. It is represented on Plate 4, fig. 16. On this section, the observer is supposed on the shore with his eyes directed south-southeast to the cliff, else the stratification seems reversed in its direction of dip. This section extends from the west inlet to the northwest point of the neck. About two hundred feet in thickness of the strata are here exposed to view, in consequence of the dip.

In some parts, the sand and loamy sand were greenish and bluish, as if formed partly of marls, like the blue and green marls of New-Jersey and the States south of it; but after careful search, I could find no fossils. The mineral characters were so strongly like those marls, as to lead me to suppose that these beds might have been partly formed of the transported grains from beds of those marls that had been washed away and deposited at the place indicated.

On the east part of Lloyd's neck, the cliffs are very high, composed of alternating strata of gravel, sand and clay. The strata dip to the westward, and the same gravel beds seen on the west and northwest sides are here nearer the top of the bank. Beds lower than those seen on the west side, are consequently visible here. The beds thus exposed consist of sand, white clay, bluish clay, and red clay. Lignite occurs abundantly in the sand, and some in the clay beds. Some of the lignite is pyritized, and some changed to hæmatite; some is wood partially decayed, and some partly decayed and partly pyritized. White clay has been much dug here, and used for stone ware; and much sand and clay have been carried from here for furnaces, as casting sand and fire clay. Fort Hill cliffs are from ninety to one hundred and twenty feet high at this place.

In one of the pebble beds, apparently the lowest one, great numbers of geodes of limonite were observed; and in many places, the limonite had cemented the pebbles, gravel and geodes, into a conglomerate.* Pebbles and loose masses of a material like this, have been seen in the drift and quaternary deposits in many parts of Long island, Staten island, and New-Jersey; and it is probable that this part of the geological series is the parent source of many of them, which have been scattered, when this layer was broken up in various places, by causes subsequent to their formation.

The gravel beds are partially cemented by a white clay, that is disseminated through it, and which is derived from a decomposed feldspar, that may be seen among the gravel and

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* This conglomerate was described under the alluvial deposits, as a recently formed material. The process of formation is still continued by the causes mentioned (vide p. 122 of this volume), but there can be no doubt but that it has been forming from the period of the deposition of that bed.

pebbles in all stages of decomposition. The sands are mostly yellowish, with some very white and fine. The clays are principally white; some yellowish and bluish. The sand, gravel and pebble beds are mostly siliceous, and contain some mica. The pebble beds show granite, gneiss, mica slate and sandstone pebbles; and some of the kind of sandstone so nearly resembling granite, of which boulders were described as occurring at three miles east of Flushing, at Whitestone, &c. Iron ore abounds here, and many tons could easily be collected on the shore. Specimens of the lignite, of the wood partly changed to rotten wood and to limonite, and others entirely changed to limonite, may be seen in the State Museum at Albany. One specimen of fossil wood, converted to limonite, may be seen there, that is about a foot in diameter in one direction, but the ligneous structure is not as distinct as in the smaller specimens in the cases. A bed of brown clay, with a thickness of about fifteen feet exposed to view, was seen on the east side of Lloyd's neck, about a mile south of Fort Hill.

On East neck, Prof. Briggs observed two beds of clay on the north shore. The lower stratum is a blackish gravelly clay, overlaid by yellowish clay. They seem to be blended with each other near their line of junction. They were undulating, but the general direction of the dip seemed to be to the south and southwest. On the northeast part of East neck, a beautiful flesh-colored clay was observed, "of a superior quality for bricks and coarse pottery."* The thickness, extent and dip of this stratum could not easily be ascertained, in consequence of numerous slides having deranged the position of the strata. It is supposed, however, from the numerous offsets produced by these slides, and the settling down of the masses of the cliff for some little distance inland, that the dip must be slightly to the north and northeast. The slides have not destroyed the timber growth, but some of the trees lean inland, as the bases of the slides slip farther onward than their tops. These clay beds belong to Capt. Raymond Sellick.

On the east side of East neck, about a mile and a quarter from Centreport, a bed of white clay occurs, of superior quality for stone-ware. It is overlaid by variegated sands, tinged with various shades of brown, yellow, white and red. These sands are used for castings, and are shipped to New-York, Boston and other places, for that purpose. The direction of the dip of these strata could not be ascertained, in consequence of the sand having crumbled down and covered most of the strata since the storm laid them there. The cliffs are here ninety to one hundred feet high.

The following section was obtained by Prof. Briggs:

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* Prof. Briggs' Notes on the Geological Survey of New-York.

	FEET.	INCHES.
1. Loose surface sand.		
2. Dark colored loamy sand and clay intermixed,	3	0
3. Yellowish and reddish sand, waved laminæ,	3	6
4. Sand, white tinged with yellow, waved laminæ,	4	0
5. The same, but differing in direction, and slightly different in color,	4	0
6. Sand, red, waved laminæ; thickness not given, probably	30	0
7. Clay, white,	0	4
8. Sand, white, tinged with red and yellow,	0	4
7'. Clay, white, same as 7,	0	3
8'. Sand, same as 8,	0	3
7". Clay, white, same as 7 and 7',	0	5
8". Sand, same as 8 and 8',	0	5

On Little neck, the hills on the west side are low, and are skirted mostly by salt marsh, with a beach next the shore. White clay was found by Mr. Briggs on the north or northwest side, similar to that of East neck. The clay has been dug for use, but the bed was nearly concealed by the superincumbent sands having crumbled and slidden down. Various kinds of clay were stated to exist on Capt. Sill's farm, adapted to the manufacture of pottery, stone-ware, bricks and fire-bricks; but the pits were filled with sand and water when Mr. Briggs visited the locality. Capt. Sill mentioned to Mr. Briggs a remarkable locality on one of the hills of Little neck, on which he stated that he had never known snow or ice, although it was on sandy ground, and on a space several yards square.*

Sandy clay was seen near Northport, in several places. It is like that observed on the east side of Little neck.

From North point to Eaton's neck beach, the cliffs are from ten to ninety feet high, but the geological structure was concealed by the sand having slidden down to the beach.

Eaton's neck was formerly a cluster of four islands, now connected by beaches and salt marshes. The principal of these islands, and the only part of the neck that is cultivated, is about two and a half miles long, and one and a half miles wide, and is composed of the tertiary strata, covered in some places by the drift and quaternary deposits. The strata of this island are similar to those of Lloyd's neck. The following is the order of superposition as nearly as could be ascertained, the sand-banks having crumbled and slidden down in many places, so as to conceal partially, or entirely, the fresh sections that had recently been exposed along the shores.

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* This, if so, and *not covered*, is a remarkable fact; but it looks so improbable, that I am inclined to mistrust it as a *quiz*. I have, however, heard of a similar spot in Guilford (Conn.), on one of the trappean hills, as it is said to be, where snow always melts as fast as it falls; but there, pyrites are said to abound in the rock, and to decompose, and the heat and the excess of sulphuric acid are a plausible and sufficient explanation.

	FEET.
1. Variegated sands, reddish, yellowish, etc. -------	20 to 30
2. White clay, ---------- ----------	2 to 4
3. Whitish sands, sometimes tinged with red,-------	20
4. Sand partially cemented by red oxide of iron, -----	4
5. Sand, grey and greenish, sometimes clayey,------	4
6. Clay, dark blackish, gritty and gravelly,--------	8

These strata are very undulating; so much so as to make it extremely difficult to determine the general dip, if they have any;* but they seem to disappear beneath the beach, when traced towards the north or south points of the island.

The dark gritty or gravelly clay (No. 6), is identical in its appearance with that on the northwest part of East neck, and found as far east as Rocky point in Southold. The stratum No. 5 is like the greenish loam described on the west part of Lloyd's neck. This stratum has been observed to contain neither lignite nor fossil wood, and the strata of sand Nos. 3 and 4 very rarely show them. The variegated sands (No. 1) often contain lignite, fossil wood, and nodules of iron ore.

The white clay of Eaton's neck has been found in many places on the west, north, south and east parts of this island, which is the main island of Eaton's neck.† This stratum of white clay is considered by those who have used it, as of the finest quality for making stone ware, and superior to that of South Amboy, New-Jersey. This clay is sold for twelve and a half cents per bushel, or more than three dollars per cubic yard. Large quantities have been dug, and the excavations show it very undulating; and some of them are so short and abrupt, that the workmen term the anticlinal curves "hog's backs." The stratum varies in thickness in short distances from one to five feet, and is overlaid by a stratum of coarse sand, and underlaid by one much finer.

The variegated sands (No. 1 of the section), are fine, siliceous, white, and various shades of yellow and red. Large quantities of these sands have been shipped to New-York, Boston, &c., for casting sand. Ferruginous sandstone, and geodes and nodules of limonite, also occur in the sands of these cliffs, like those of Lloyd's neck. The cliffs are elevated from fifteen to one hundred and twenty feet, in various parts of the island.‡

At Freshpond creek in Huntington, flesh-colored or salmon-colored clay occurs on the farms of Bryant Rodgers, and Matthew Gardner. The clay is similar to that of East neck. On Mr. Rodgers' farm, the clay has been excavated sixteen feet without finding the bottom. The dip is slightly towards the Sound, and numerous slides are the consequence. The slides

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* It is presumed that these strata have no *general* dip, except we take a very enlarged view of it, as beds similar to No. 6 are found at about the same level, nearly as far east as Oysterpond point; and the white clays even farther on Plum and Gardner's islands, Shelter island, etc.; and variegated clays, etc., on Martha's Vineyard.

† Another island, very small, and not elevated more than twenty or thirty feet above the tide, is in the line of the long beach connecting Eaton's neck with Long island. Two others, also small, on the south side of the neck, are called Duck islands. They are of the same geological age as the main island of Eaton's neck.

‡ Mr. Briggs was employed to examine the shore from Huntington to Wading river, and most of the facts on Eaton's neck are taken from his notes.

have caused irregular broken steps or terraces from the back to the top of the cliff, called the "broken grounds," about a quarter of a mile long, and twenty to twenty-five rods wide. The bank is about sixty feet above the tide level. White clay also occurs on Mr. Rodgers' farm. Clay balls are also found near Mr. Rodgers', on the beach. They are reddish, and doubtless come from the bed of reddish clay.

On the east side of Stonybrook harbor, clay occurs near Mr. Wickham's mills; also about one mile south of Stonybrook harbor, on Mr. Mills' farm. Mr. M. dug a well here one hundred and eighty feet deep. A stratum of clay, five feet thick, was passed through near the surface; the remainder of the depth was through sand and gravel, until they reached the solid rock at one hundred and eighty feet below the surface.

Near Crane point, ferruginous sandstone, conglomerate, and nodules of iron ore were found on the beach, that had fallen from the cliffs; but as the sand had slidden down, the strata of which the cliff is composed could not be seen. These masses of sandstone, conglomerate and iron ore, were like those of Lloyd's neck, and the formation is doubtless the same. The cliffs from Stonybrook harbor to Crane point are twenty to seventy feet high, but their stratification could not be seen. Judging from the materials of the sand-banks, and the rolled lumps of clay on the beach, the strata are probably the same as on Lloyd's neck, and West and East necks.

At Old Field light-house, a well of twenty feet passed through a few feet of superficial sand and gravel, and the remainder through the variegated clay. White clay also occurs near this place.

Near Setauket is a yellow ochreous sand, that has been used for making yellow ochre. Ten bushels of the sand yielded two and a half of ochre.

On Van Brunt's neck, Brookhaven township, nodules of iron ore were found on the beach. They are like those of Lloyd's neck; and the geological formation of the cliffs, and the neck, is supposed to be similar. The sliding sands from the cliffs sixty to ninety feet high, concealed the stratification.

On the shore of Mount Misery neck, fossil wood converted into iron ore, and loose rolled lumps of clay, were found at the base of the sand cliffs, and were like those of Lloyd's neck. Clay has been dug on the west side of Mount Misery, for bricks.

The sandy gritty clay was found near the shore at Rocky point, between Miller's place and Swezey's landing. It also occurs at Swezey's landing, and between that place and Wading river.

The whole shore from Eaton's neck to Oysterpond point, except where marshes or beaches intervene, is skirted by the sands of the Long-island division, containing beds of clay, capped in many places by the drift and quaternary deposits; but most of it, at the time examined, had its stratification more or less concealed by the crumbling and sliding down of the sands, except between Wading river and Oysterpond point, which I examined soon after the storm of the eleventh and twelfth of October, 1836.

The dark colored gritty clay, containing sand, gravel and pebbles, was observed about a mile and a half northeast of Southold on the shore. Its strata are very undulating. In the

arched clay beds near Brown's point (vide Plate 4, fig. 7), are found layers of a fine, fat, reddish brown clay. It splits regularly into oblique-angled parallelopipeds, with a constant angle between its corresponding faces. The general form of these rhombic masses is like that of feldspar, except that none of the angles are right angles.

Near Oysterpond village, the cliff, on the Sound side of the isthmus, was washed away at the base during the storm. The dark colored gritty clay, with its associated sand and gravel beds, surmounted by the drift stratum containing boulders, were exposed to view.

Opposite Greenport, on the Sound side of the isthmus, the base of the cliff was washed away at the same time, so as to expose its strata. At the base, the cliffs are composed of horizontally stratified sand, gravel and pebble beds of variegated colors; red, yellow, white and intermediate colors. The upper part of the cliff is of the greenish and bluish loamy deposit, containing great numbers of boulders and blocks, some of which are of great size.

At Horton's point, the blue gritty gravelly clay was seen like that on the shore near Southold, and described in many places along the north shore of Long island; also between Horton's point and Duckpond point, two and a half or three miles west of the former point.

At Roanoke point, and for two or three miles east, the cliffs were high, and the stratification was exposed to view by the inroads of the sea during the same storm (eleventh and twelfth of October, 1836). The strata of the Long-island division, towards the base of the cliff, of light colored and some variegated sands and bluish clay, are overlaid by the drift deposit, and that by the quaternary sands and clays. Slides are here common. The superposition, and the effects of springs producing quicksands, slides and ravines, are illustrated on the woodcuts, figs. 1 and 2, on page 33 of this volume.

Near Hudson's point, three beds of clay may be seen: the upper greyish; the middle bluish, and containing gravel and pebbles; and the lower brown, with a tinge of red. They form a thickness of sixty to one hundred feet.

The gravel and pebble bed mentioned as occurring in the tertiary on Lloyd's neck, and which has been seen in many places, was seen in crossing every deep ravine near the north shore of Long island, between Miller's place and Smithtown; and in fact, in nearly all the ravines to Flushing on the west, and to Nepeague beach on the east, where the hills are one hundred feet or more in height.

A range of clay beds extends from near Smithtown to Riverhead, a little south of the road. Gravel and loamy gravels form a belt parallel, a little north of the clay; and a belt of loose sands, still further to the north. Clay was seen near Corum, a little to the west of the village, near the brick-yard. It is blue, more or less variegated with red. The *position* of this clay is illustrated on Plate 4, fig. 11; but the figure has been incorrectly copied. The first and third layers are loam, the second gravel, the fourth clay. The laminæ of the gravel bed are not parallel to those of the loam, and these latter are unconformably placed over the clay. The clay bed seems to have been bent downwards, and the loam deposited in the valley, as the bed is thicker in the deeper part of the valley. The gravel seems to have been washed over this, after some farther derangement of the strata producing a slight fault. The *figure* does not shew all these circumstances.

In Bruce's Mineralogical Journal, various facts on the geology of Long island are stated.

White clay underlies the sand hills on the north side of Long island, and in many places is tinged with iron, so as to make good ochre. This ochre may be traced from Musquito cove on Hempstead harbor, to Newtown, in a southwest course, and shows itself in the following places, viz: West side of Hempstead harbor, opposite Musquito cove; at Plandome, two miles farther; head of Cow bay, another mile; again in a hollow several miles farther on the same course, near the head of Little neck bay in Flushing; and again in Newtown. Balls of pyrites are often found in this clay.* The ochre on Cow neck is on Mr. Dodge's farm, and is above high-water mark, on the west side of Hempstead harbor, and is easily accessible.*

(a). *Section of a well dug at Great neck, North-Hempstead, for Messrs. William and John Mott.*

	FEET.
1. Hard reddish earth, requiring a pick to dig,	9
2. Light colored loose sand,	21
3. Dark red loose earth; the upper surface strewed with clam, oyster and scallop shells,	15
4. White beach sand, containing rotten wood,	6
5. Fine micaceous sand, with lumps of tough red ochreous clay,	40
	91†

(b). *Section obtained in digging a well on land of J. Rapelje, on the road across the head of Cow neck, between Great neck and Hempstead harbor.*

	FEET.
1. Sandy loam and some gravel,	10
2. Compact clay,	1
3. Sand and gravel,	9
4. Gravel and rounded stones of quartz, granite, breccia and argillaceous iron-stone,	10
5. Masses of grey granite jammed together,	5
6. Gravel like the fourth stratum,	3
7. Hard loam,	3
8. Soft clay,	0½
9. Sea sand and coarse gravel and pebbles alternating,	48½
	90‡

* Dr. Mitchill on the Geology of Long island. (Bruce's Mineralogical Journal, Vol. 1, p. 129.)
† Id. Ib. p. 202. ‡ Bruce's Mineralogical Journal.

(c). *Section of a well at Mr. Johnson's in Brooklyn, between Wallabout and Guanas,* dug in April*, 1811.

	FEET.
1. Sandy loam,	3
2. Hard concreted clay, sand and stones colored with iron, and requiring a pick to dig, composed of gneiss, hornblende and brittle slate,	15
3. Loose gravel and greyish sand, with thin streaks of gravel; the gravel of quartz, basanite, breccias, mica slate and red sandstone,	20
4. Alternating layers of two or three feet of sand and gravel, containing coarse green soapstone (serpentine?) in addition to the materials of No. 3,	17
5. Sand and gravel in alternating layers; the gravel beds contain sea shells, mostly clams and oysters, but the sand contains none,	29
	84†

Clay has been seen in the following places, in addition to those heretofore mentioned:

1. Clay is found beneath the sand, between Riverhead and Canoe place, in many places. It is also found on Mecomick river, three miles below Riverhead; one hundred rods north of Riverhead; one mile southwest of Riverhead; and is common in the sand hills.
2. Along the shore of Great Peconic bay, in several places; one mile east of Canoe place; on Sebonic neck; Cow neck, near Mr. White's; two and a half miles northwest of Southampton, near West neck.
3. Clay underlies the sand and gravel beds of Great and Little Hog necks in Southampton; and is found at the White hills on the west side of Shelter island. White clay on Mr. Tuttle's farm, on Shelter island.
4. Near Sag-Harbor, at the brick-kilns. The clay is much intermingled with pebbles and gravel, and is overlaid by sand.
5. At Sand's point, clay containing lignite is said to occur.‡ I have not seen them *there*.
6. Near Oysterbay, are several localities of clay. I did not see them. Judging from the color of the sands, the clays must be of the same characters as those of Lloyd's and West necks.
7. On Hog island, or Middle island, Oysterbay township, blue clay was seen on the north-northeast, south and southwest sides, and white clay on the east and west sides, twenty feet thick, but more than one half this depth below low-water mark. They are overlaid by sand and gravel beds, and by the drift. Ochreous earth on the east side.
8. Clay was also seen near Dasoris, on Mr. Latting's land.
9. On Robin's island, in large quantities.

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* This name is and has been variously spelled, but this is believed to be the proper mode. It has been spelled *Gowannus, Cowonnus, Cowannus*, &c.

† Bruce's Mineralogical Journal.

‡ American Journal of Science, Vol. 7, p. 35. Finch, on the Tertiary of the United States.

10. On Plum island. Beds have been worked many years, for bricks and coarse pottery. The localities *originally* worked have long since been washed away,* in consequence of the inroads of the sea, which is making constant encroachments in some parts.
11. Near Greenport, three-quarters of a mile west, clay is dug for pottery, and is manufactured at Greenport. Many localities have been observed between Greenport and Southold, south of the main road. It abounds at Hashamomuc, two or three miles east of Southold, both east and west of the meadows that lie south of the beach.
12. Betwen Freshpond creek and Wading river, in many places. Round lumps, rounded by the bouldering of the surf, were seen on the beach, and slides of the cliffs were common.
13. Common almost every where in the Smithtown valley, within a few feet of the surface. It is the sandy gritty clay. I saw localities of it at one, two, and two and a half miles south of Smithtown. A locality seven miles south of Smithtown yields a gritty clay of a brick red color, but the parts free of grit are extremely plastic and unctuous.
14. Clay is found two miles east of Huntington, on Great Cow bay.
15. North of Jamaica about one mile, is an inferior kind of brick earth. A brick-yard here turns out about 350,000 bricks per annum.
16. Near Musquito or Glenn cove, clay is found. A brick-yard here yields about 300,000 bricks per annum. Tobacco pipes were manufactured from one of the clay beds of Musquito cove, in 1801. (Vide Mitchill, Medical Repository, Vol. 4, p. 200.)
17. In the excavations for grading the streets in the south part of Brooklyn, thin strata of clay were found.
18. On Staten island, the northwest part contains a red gritty clay, that it is necessary to perforate to obtain water. I saw one excavation for a well, in this material, thirty-seven feet without going through it, between the trap and serpentine ranges.
19. Clay occurs by the road side at Lester Davis', in Corum, Brookhaven township. Reddish sand overlies the clay, partially united by the red oxide of iron; dark colored sand overlies the last, and is overlaid by gravel partially cemented. Blue clay also occurs on Mr. Jeremiah Roulen's farm, near Corum.
20. Clay occurs on the farm of Mr. Obadiah Smith, near Freshpond creek. Bricks have been made here. The clay was dug into seven feet, without penetrating through it.
21. On Strong's neck, which is an island at high water, clay is found. It may be seen in the bank at low water. Also near Strong's neck, on Mr. Jesse Woodhull's farm. This also is at low-water mark. The cliffs of Strong's neck are of little height above the sea, generally not more than twenty feet.
22. Blue clay was found at the depth of ninety feet, by Mr. J. Edwards, in Southampton township, about two or three miles from Sagg village, in the hilly region. Mr. E. dug one hundred feet for water, most of the distance through beds of sand and gravel. Concretions of indurated clay, like *clay balls*, were found in the clay. They were described as smooth and round, as if turned in a lathe. I saw none of them, but from Mr. E.'s description, have no doubt that they were similar in form, composition and origin, to the clay balls of segregation so common in the clay beds of the valleys of the Hudson, Connecticut, &c.

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* This information was communicated by Mr. Tillinghast, who is a native of that island, and has witnessed the wasting and washing away of the cliffs by the action of the currents and waves.

It is entirely unnecessary to specify localities of *sand* on Long island, as this material is found abundantly on every square mile of the whole island, even under the salt marshes. Those more rarely seen, as the black iron sand, and the red garnet sand, are found more or less abundantly on *every beach*, after a storm. The sands, important in determining the geological position of particular strata, have been generally alluded to, in discussions of the local geology of the island.

The same remarks will also apply to the beds of gravel and pebbles, except that they are not so frequently seen, are more or less local, and generally are below the natural surface of the ground.

Ochreous clays have been mentioned. A locality of *ochreous earth* occurs on the road from Easthampton to Montauk point, east of Nepeague beach. It appears to be very abundant, and may be usefully employed perhaps for the manufacture of ochre, or to mix with iron ores in smelting.

Columnar argillaceous iron ore was observed by Dr. Samuel L. Mitchill, on his farm in Plandome, Long island, and described by him.* It seems to have been a concretion of a flattened ovoidal shape, two feet five inches broad and four inches thick in the middle, diminishing in thickness toward the edges. When lying in its native bed of heavy loam, the columns, which presented their ends to view, had the appearance of a tessellated pavement, only the columns were pentagonal in form. The ends were most perfect, and about one and a half inches across. When raised and separated from the mass, they were found to be larger at the ends than in the middle, so as to bear some resemblance in form to the pestle of a mortar.†

I have seen specimens of similar character, among the loose masses of iron ore washed from the cliffs. They rarely assume the form mentioned, but more frequently one in the form of nodules or flat masses.

Fossils of Long Island.

1. *Bones.*

At the brick-yards on West neck, Huntington, bones and shells are said to have been found in the clay; but the person who communicated the information, said it in such a way, as to lead me to distrust his sincerity.

At Brown's point, Southold, I was told that a bone was dug from the sand-bank, about twenty feet below the surface, between two layers of clay. It was said to be white, about eighteen inches long, two inches diameter, with large roundish heads.

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* Medical Repository, 1799, Vol. 2, p. 219.

† At the time of this discovery by Dr. Mitchill, the question as to the aqueous or igneous origin of trap rocks was not settled, and two parties discussed the question with much warmth. Everything having any bearing on this subject was urged by one or the other party, to support their peculiar views. Dr. M. in consequence of the similar form to the columnar form of basalt, urges this example as settling the aqueous origin of trappean rocks.

On Staten island, a bone was said to be dug from a depth of —— feet.* This bone I saw and obtained, but it seems to be too fresh and recent in its appearance to have been buried under such a depth of earthy materials.† It probably belongs to the *Testudo*.

2. *Shells.*

(*a*). Shells were dug from a well at ninety feet, near Plandome church, three miles north of the court-house, Queens county, at Mr. Docherty's. Mud, also, like marsh mud, was said to have been dug up.

(*b*). On Prospect hill, Flatbush, shells were found always, it was said, in digging wells.

(*c*). Shells are said to have been found in almost all the wells at Brooklyn, and were very abundant at the corner of Jay and Prospect-streets, and at the corner of Washington and Concord-streets.

(*d*). Shells were found in digging a well on Cow neck, three and a half miles from Sand's point, on Henry Demelt's farm, at sixty feet from the surface, and not far from the mills.

(*e*). Mr. Duryea, an intelligent well-digger, informed me, that he almost always found shells in the hilly region of the island, in digging wells, and especially where the soil is tough and hard, like that north of Jamaica. He also stated that he had found shells *on* the *boulders*, adhering as we see them on the shore.

(*f*). Dr. Paten dug up shells at one hundred and three feet, wood at forty feet, and found water at one hundred and six feet, at the house next west of the half-way house (Howard's) between Jamaica and Brooklyn.

(*g*). Fossil shells were dug up at the depth of about one hundred feet, on the fort on Governor's island, New-York harbor.

(*h*). Oyster shells are said to have been dug up at great depths on the hills northwest of Jamaica, in digging wells.

(*i*). Mr. Finch says, shells are found every where on Long island, forty or fifty feet below the surface, and consist of the *Venus*, *Ostrea*, *Murex*, &c.‡ They are not found, I believe, in digging wells, except in the *hilly region*, or near the base of the hills. I do not know of an instance in the great south plain of Long island (which occupies one half of its area), except near the base of the hills or in the deeper valleys.

(*j*). Wells, on the ridge of hills running through Long island, have developed oyster shells at great depths in many places.§

(*k*). At the Navy Yard in Brooklyn, shells were found in digging down a hill.§

(*l*). Shells of clams and oysters are found almost universally in Brooklyn, New-Utrecht,

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* The bone is in the State Museum at Albany. I do not recollect the depth (which is indicated on the label of the specimen) at which it was stated to have been found, but think it was between sixty and one hundred feet.

† I am familiar with the aspect of fossil bones, numbers of which I have taken from their natural resting places.

‡ American Journal of Science, Vol. 7, p. 36. § Ackerly on Coal: Bruce's Mineralogical Journal, Vol. 1, p. 84.

Flatbush and Newtown, at sixty feet below the surface. A periwinkle was found at forty-three feet below the surface at New-Utrecht.*

(*m*). Clam and oyster shells were found at sixty-seven feet below the surface, in a ridge of hills, and at intermediate depths, near the Narrows in New-Utrecht; and a murex or large periwinkle was also found at this depth.*

(*n*). Clams and oyster shells were found from thirty to fifty-two feet, in the fort at the Narrows in New-Utrecht. They were in an earthy mass of a reddish color, and so hard as to require a pick to dig it up.†

(*o*), (*p*). The sections on pages 258 and 259 of this volume, show the occurrence of shells in Brooklyn at the depth of sixty to eighty feet; and on Great neck, North-Hempstead, at about thirty feet.

(*q*). Shells were dug up at the depth of eighty feet, on the Bald hills, two miles south of Corum, by Mr. Isaac Overton. They were in a black tough earth, like that called *hardpan*, composed of clay and gravel. Mr. Overton described them as clams and oysters.

(*r*). Shells were also dug up at twenty-four feet below the surface, at Swesey's mills, in Brookhaven township.‡

(*s*). Shells, and a log eight to ten inches diameter and ten feet in length, said to be pine, were dug up at West Rocky point, seventy feet below the surface.

(*t*). Oyster shells were dug up at Corum, by Mr. Overton, at forty feet deep.

(*u*). In Middletown, on the farm of John Hoel, a shell was found at the depth of thirty feet, like the mactras common on the coast (*Mactra solidissima?*).

(*v*). In Brookhaven, one mile west of Wading river, round clams and oyster shells were stated to have been found at the depth of sixty-five feet from the surface, on the farm of Zophar Mills, in digging a well. Mr. Mills says the shells were twice as thick as usual. They may have been *gryphææ* or *exogyræ*.

(*w*). On Hog neck, Mr. Cory found a shell of a round clam, as he calls it, at the depth of thirty feet, in digging a well.

(*x*). On Staten island, near Richmond, shells are stated to have been found at a depth of more than one hundred feet.

This is all the information I have been able to collect in regard to fossil shells. The evidence is such as to be worthy of all credit. I have consulted many individuals of undoubted veracity, and who had every appearance of sincerity, who stated that they had found, or seen the shells as stated. I have copied similar information from various authors; so that the evidence may be considered complete, to authenticate the facts. On the other hand, on inquiring to see the shells, no one of those who found them, and had preserved specimens as they

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* Bruce's Mineralogical Journal, Vol. 1, p. 132; and Medical Repository, Vol. 3, p. 380.

† Bruce's Mineralogical Journal, Vol. 1, p. 362.

‡ Lt. Moses Scott, in the discharge of his duties as one of the engineers of the Long island railroad, has ascertained the levels of a great number of localities, and he remarked that the depths at which the shells were obtained from the two last localities brought them to nearly the same uniform level.

supposed, has been able to produce one. I have examined the cabinets that might be supposed to contain them, as that of the Lyceum of Natural History of New-York, that of the Brooklyn Naval Lyceum, and that of Dr. S. L. Mitchill, with the hope that by means of the fossils, the proper place in the geological series for the strata under consideration could be ascertained; but I have not been able to find a single shell. I have also attended at the digging of wells, examined the earth of those that had been previously dug, explored the coasts where extensive sections were freshly exposed to view, excavations for railroads, grading streets, cellars, sandpits, etc.; but no traces of shells were observed except in a single instance, and there only small fragments, surrounded and worn by attrition, so as to be incapable of any specific determination.

The localities of the shells, their depths, and the strata in which they are found, show beyond doubt that most of them are in the strata *below the drift;* some, perhaps *in the drift;* and that *none, or very few,* are in the *quaternary deposits.*

3. *Lignite and Fossil Wood.*

(*a*). Mr. Finch mentions lignite at Sand's point.*

(*b*). Fossil wood was dug up at Swesey's landing, now called Woodville, Brookhaven township, in digging a well. In another spot at this place, Mr. Skidmore dug a well one hundred and eighty feet deep, and at sixty feet found a stick of wood ten inches in diameter and eight or ten feet long. The remainder of the depth, one hundred and twenty feet, was through sand of nearly uniform character.

(*c*). I found lignite in the sands on the west or northwest side of Lloyd's neck, Huntington (vide Pl. 4, fig. 16).† Some of it was lignite reduced to a carbonaceous paste; still retaining, when taken from the sand, the fibrous texture of the original vegetable, but cracked across, and soft as clay.

(*d*). On the east side of Lloyd's neck, Mr. Briggs and myself, both separately and together, at different times, found lignite and fossil wood abundantly. It was in the sand beds above the white clay. The fossil wood was in some instances partly fossilized by limonite, and partly in the state of partially decayed wood; other specimens were entirely changed to limonite, only they retained some of the carbonaceous matter of the original ligneous mass; others still appeared to be entirely limonite, but showing the ligneous texture as distinctly as the wood itself. It was in long flattened masses, like wood partially crushed by the superincumbent weight, so that a cross section was of an oblong elliptical shape. Hand specimens may be seen in the State Museum at Albany. One large specimen in which the ligneous texture is very indistinct, and about one foot in diameter, may also be seen in that collection, and

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* American Journal of Science, Vol. 7, p. 35. It is thought that Mr. Finch meant Eaton's neck, or Lloyd's neck, instead of Sand's point, from his description.

† The dip is represented on this figure as greater than it really is, in consequence of the original figure having been incorrectly copied.

weighing from fifty to one hundred pounds. Most of the specimens were found in the high bank next the shore, at what is called Fort Hill, and East Fort, on Lloyd's neck. The bank is probably one hundred feet high.

(*e*). Near Coldsprings, (two miles southwest) in Oysterbay township, fossil wood was found in digging a well on John or Thomas Velsor's land. The depth at which it was found was not stated.

(*f*). Lignite was found at the depth of fifty feet, at Mr. Wilson's well, near Coldsprings, Oysterbay township. It was so hard as to require to be chopped with an axe.*

(*g*). On East neck, Huntington, Capt. Sill dug up lignite, which he called coal, at the depth of thirty or forty feet. One piece was nine or ten inches in diameter.

(*h*). On the north or northwest side of East neck, Mr. Briggs found fossil wood changed to limonite, at the locality of white clay.

(*i*). On Eaton's neck, he also found lignite and fossil wood in several places. At the south end of the main island of Eaton's neck, the cliffs are eighty or ninety feet high; and the sands above the white clay contain fossil wood and nodules of limonite, like those of Lloyd's neck. He found one mass of fossil wood eighteen to twenty inches in diameter, some parts of which were in the state of rotten wood, some had been converted into iron ore, and in others the decayed parts had been replaced by sandstone. This large mass was so tender that hand specimens only could be obtained from it. It could not be removed. Specimens of similar character, but smaller, were found in the sand-beds above the white clay, for more than half a mile along the shore. Few of the specimens were proper *lignite*, but were wood more or less fossilized by limonite, and containing more or less carbon and rotten wood. Their fossilization is doubtless due to the same cause as the formation of the nodules of iron ore, and of ferruginous sandstone and conglomerate, namely, the decomposition of pyrites. Mr. B. found fossil wood also on the north shore of Eaton's neck, and on the east shore. Specimens from all the localities were collected,† and all have the same geological position.

(*j*). Fossil wood was found twenty-five feet below the surface, on land of Mr. Napier, three miles west of Jamaica.‡

(*k*). Carbonized wood, incrusted with pyrites, was found in Newtown, fifty feet below the surface; also a body of a tree lying across a well at forty-five feet; another at sixty feet, a little east of Westbury meeting-house; another, with the bark still adhering, at forty feet, near Eastwood's; another at Success, on the summit at the ridge of hills, thirty feet deep.‡

(*l*). Lignite, or charred wood, has been found on Cow neck, and at Newtown. That on Cow neck was on the farm of Joseph Dodge. Two shafts were sunk here to obtain coal, which was supposed to exist, in consequence of the deceptive appearance of fragments of lignite.§

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* Bruce's Mineralogical Journal, Vol. 1, p. 362.

† Several boxes of specimens collected by Mr. Briggs, who was sent to many interesting localities to collect specimens, never reached their destination in Albany. The suite of Long island is not as complete as it *would* have been if they had been received.

‡ Ackerly on Coal, in Bruce's Mineralogical Journal, Vol. 1, p. 132.

§ Mitchill on the Geology of Long Island, ibidem, Vol. 1, p. 129.

(*m*). On Staten island, blackened wood (lignite) was said to have been found in digging a well at the depth of sixty feet, about half way between Richmond and the south shore of the island.

(*n*). I found lignite abundantly, in the blue astringent clay containing pyrites, near Rossville on Staten island. Many specimens of the lignite were bored by the *Teredo*, and the cavities filled with pyrites; and the fragments of lignite that lay on the surface were covered with a white and greenish efflorescence of the sulphate of iron, in consequence of the decomposition of the pyrites. This locality is in a ravine, where numerous small slides have occurred, a little northeast of Rossville, near a small stream.* This blue pyritous astringent clay is precisely similar to the dark pyritous clay containing pyrites and lignite, near South-Amboy, Matavan point, Cheesequake marsh, and Middletown point, and which *underlies the green marls of New-Jersey*, and *overlies the beds of white and mottled clays of New-Jersey*,† and is the same as the blue and brown pyritous clays above the white clays of Long island. The blue clay at the locality near Rossville, where exposed to the weather, was

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* It contains an abundance of pyrites in nodular crystalline masses, and of all the imitative shapes of the segregated clay balls of the clay beds of the Hudson and Connecticut valleys. Sometimes a shell, and sometimes a bit of wood, serves as a nucleus.

† From the similarity of the clays and sands of Long island and Staten island, to those of New-Jersey below the marl deposits, some sections that I made on the north coast of New-Jersey, south of Staten island, where fresh sections were exposed by the inroads of the sea at the great storm of the twenty-ninth of November, 1830, and by recent excavations at the clay pits, are here inserted. The white and potter's clays of Amboy and Woodbridge (New-Jersey), are the same as those of Lloyd's, Eaton's, West and East necks, and other places on Long island. The same may be said of the dark micaceous and sandy clay, of the mottled clays, of the sands, gravels, conglomerates, etc.

1. *Sections of Mr. Morehouse's clay-pit, on the shore of Raritan bay, half or three quarters of a mile east of South-Amboy landing.**

	FEET.
(*a*). Surface sand (not at the pit, but a little south),	10
(*b*). White sand with yellow lines,	10
(*c*). Yellow clay,	4
(*d*). Blue clay, almost white when dry,	5

In this lower layer of clay, leaves of various kinds have been found between the laminæ. This clay is used in making glass-house crucibles.

2. *Section of a clay-pit about one mile east of the preceding.*

A railway of wooden rails is laid from the pit to the bay, where vessels receive their loading from the cars.

	FEET.
(*a*). Yellow sand,	4 to 10
(*b*). Ferruginous conglomerate,	½ to 1½
(*c*). Variegated clay, yellow and red,	6 to 7
(*d*). Plastic blue clay, nearly white, down to the level of the bay,	6
	24½

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* Now the railroad depot and landing.

covered with a greenish incrustation of green sulphate of iron. The same kind of clay and lignite may be seen on the shore near Rossville.

I saw lignite in the sand and gravel beds on the shore near the southwest light-house, on Staten island.

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3. *Section of a clay-pit about three hundred yards east of the preceding, on the shore of Raritan bay.*

	FEET.
(*a*). Yellow sand,	2 to 10
(*b*). Ferruginous conglomerate,	2 to 3
(*c*). Yellowish clay,	6 to 8
(*d*). Plastic bluish white clay,	6 to 8
	16 to 29

The clay (*d*) is used for stone ware. The strata seem to dip very slightly to the east, perhaps one-fourth to one-half of a degree. The section terminates about fifteen feet above the level of the bay.

4. *Section of the bank on the shore of the bay, about one hundred yards east of the last section, at the point.*

	FEET.
(a). Sandy loam,	3
(b). Yellowish clay,	7 to 8
(y). Brown clay,	1
(d). Sand and clay,	1½
(e). Brown clay,	1 to 2
(*a*). Yellow sand and clay,	2
(*b*). Ferruginous conglomerate at the level of low water.	
	15½ to 17½

5. *Section of Morgan's clay-pit, one hundred yards south of the preceding.*

	FEET.
Yellow sand,	3 to 10
Ferruginous conglomerate,	2 to 3
Yellow clay, mixed with sand,	10 to 10
Brown clay with small fragments of lignite,	1 to 5
Grey clay,	1 to 3
Blue clay, nearly white when dry,	8 to 8
down to the bottom of the pit, which is about three feet above high-water mark.	
	25 to 39

The strata are covered with sand and rubbish thence to the water.

About one hundred to one hundred and fifty yards to the south of this section, the brown clay of this section makes its appearance on the shore, emerging above the sand of the beach above high-water mark. There were some traces of this clay among the rubbish of the clay-pit of the last section, fragments of lignite and masses of pyrites being common. Farther south, the brown clay gradually emerges more and more; and at the distance of three quarters of a mile, it is ten or twelve feet above high-water mark, and underlaid by a yellow clay mixed with sand like (*d*) in section 4. The sands and rubbish of the beach conceal the strata below the clay, except at this place; and even here, only a small part of the yellow sandy clay is visible. Lignite is disseminated through the brown clay, generally in small pieces and particles, but some large masses like trunks of trees were seen. Pyrites in various formed masses, and like the clay balls presenting all kinds of fantastic shapes, are very abundant. Hundreds of tons might be picked up at low water, and might be economized in the manufacture of copperas, alum, sulphur, and sulphuric acid on a small scale.

At Deep gully (a little east of Middletown point), Matavan point, and the ravine through which Middletown creek flows a little west of Mount Pleasant, the clay in many places is filled with iron crusts, apparently by the decomposition

The facts stated in the note on the brown clays and the marls of New-Jersey, together with the observations and investigations of Prof. H. D. Rodgers and others, demonstrate that the position of the marl deposits is above the white and mottled clay beds, with their reddish

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of lumps of pyrites tending to indurate the clay around them. This clay, in the part below the lignite stratum at Matavan point, contains balls and ovoidal masses of indurated clay, unlike any of the clay balls I have ever seen. The pyrites in the brown clay frequently contain some organic body as a nucleus. These occur more abundantly one quarter of a mile west of Matavan point, than at any other locality I have seen. Scales of mica, as far as I have observed, are always to be found by close examination in the brown clay.

At Matavan point, the following section was obtained when fresh exposed, after the fall of the cliffs during the great storm of November twenty-ninth, 1830.

6. *Section of Matavan point, on the left of the mouth of Middletown creek into Raritan or New-York bay.*

	FEET.
(1). Vegetable soil, sand, etc.	1 to 1
(2). Yellow gravel, frequently aggregated,	5 to 6
(3). Ashy and buff-colored clay, sometimes yellow and highly ferruginous,	2 to 6
(4). Conglomerated sandstone,	1 to 2
(5). Sand, clay and lignite in numberless strata, from one-twentieth of an inch to several feet thick,	30 to 33
(6). Ferruginous conglomerate passing into ferruginous sandstone,	1 to 2
(7). Brown clay containing indurated clay balls, pyrites and iron crusts, to high-water mark, where it is concealed by the beach,	8 to 8
	48 to 58

The lignite in stratum (5) is generally more abundant near the bottom than above. In one place near the bottom, the lignite was a foot thick; and above, in layers from an inch to one-twentieth of an inch thick. The clay in some parts forms the principal part of the stratum, with sand in very thin layers; in others the sand forms the mass, with thin layers of clay and lignite. These strata present a pleasing view to the observer; beautifully white and yellow sands, alternating with the brown clay and black lignite in almost countless strata. The lignite bed at the lower part of the stratum consists of the fragments of plants, from the size of large trees, to small plants, intermixed with limbs, branches and twigs. Many of the fragments are bored by the *Teredo;* and in many of the pieces, the holes are filled with crystallized pyrites. The sand, clay, and lignite of this stratum are all impregnated with copperas, so much so as to give these materials in some places a greenish color; and a ferruginous sandstone is forming on the beach, in consequence of the leaching of this salt into the sand of the beach, and its change of composition.

Travelling southeast from Middletown point and Mount-Pleasant, the brown clay is found in the gullies by the road-sides, in crossing the ravines. Proceeding higher in the hills and in geological level, we see only reddish sand and sand mixed with clay; and above this, grey and black marls are found. Sand and gravel overlie the marl at Holmdell or Baptistown, or Middletown Academy (as the village is called), a few feet in depth. Shark's teeth, gryphææ, exogyræ, terebratulæ and belemnites, with bones of saurians and fishes, are common in the marl pits. Some *Ostrea falcata* and *Terebratula sayi* were found.

7. *Section of J. Holmes' pit, half a mile north of Holmdell.*

	FEET.
(1). Clay,	4
(2). Grey marl,	5
(3). Blue and black marl, depth unknown, exposed,	5

Small pieces of lignite are found in this pit. Belemnites were very numerous in some parts of this pit, and large exogyræ. Some of the latter, when entire must have weighed several pounds (five or six at least). The convex part of

and variegated sands, and principally above the brown clay. The geological position in which it may be found, if it occurs on Long or Staten islands, is thus reduced to very narrow limits, namely, between the pyritous clays, sands containing lignite, and their associated clay beds,

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one was more than two inches thick.* Daniel Holmes' and Holmes Vanmetrie's pits, within a mile, gave the same strata. In some places where the small streams have cut through, the marl was observed twenty feet thick, and the blue and brown pyritous and micaceous clay was exposed beneath. A stratum of sand sometimes intervenes between the marl and brown underlying clay, as may be seen in one of the marl pits (the first) between Mount-Pleasant and Middletown Academy. The blending and intermixture of the materials of these strata, at and near their junction, may there be seen.

Shells, shark's teeth, and bones of saurians are found in Mr. Daniel Conover's pit, two miles south of Holmdell. I have some vertebræ of a saurian from that place, and a fragment of a jaw, similar in the arrangement of its teeth to the *Esox osseus.*

Mr. Hartshorn's marl pit, two miles north of Freehold, contains grey indurated marl and black marl. The grey marl is replete with the *fragments* of shells. The lower of black marl is the best manure, and contains very large shells, "a species of ostrea." Bones of a large fish, and vertebræ of a saurian, were obtained from a pit one quarter of a mile north of Hartshorn's mill.

All these marls, and even the dark colored underlying clay, contain more or less of the green grains, which, when in large proportion, exert so powerful a fertilizing and stimulating effect on vegetation. The marl beds at Squankum are composed almost entirely of these green grains.

8. *Section of the Squankum marl beds, nine miles southeast of Freehold.*

	FEET.
(1). Soil of sand and gravel,	1 to 5
(2). Grey marl (sometimes wanting),	4 to 5
(3). Green marl, about,	15
(4). Sands and gravel (unknown depth).	

The organic remains are very numerous. I filled my pockets with shark's teeth in a short time. Imperfect casts of the various testacea of this stratum were also abundant. The lower jaw of a *gavial* (as it has been pronounced to be by various gentlemen who are familiar with comparative anatomy), was found at or near these pits, in the green marl, and presented to me by Mr. Mahlon Spencer.†

9. *Section of Fuller Horner's marl pit, half a mile north of New-Egypt.*

	FEET.
(1). Sand, variable in thickness according to the undulations of the surface.	
(2). Grey marl, indurated, with some traces of shells,	0½
(2'). Grey marl, moderately hard,	4
(3). Brownish sandy marl, with some green particles and decayed shells,	4
(3'). Same, with shells, and indurated,	2
(4). Grey marl, with great numbers of shells,	1
(5). Brown marl, with many shells,	4
(6). Green marl, with some shells,	3
(7). Black marl, at least	5

The shells in this pit are mostly terebratulæ of different species, generally not more than two species in each stratum, or the same species repeated in the different strata. The *T. harlani* and *T. fragilis*, are most abundant, and at the bottom of (6) are most perfectly preserved.

The Gryphæa convexa and G. mutabilis are the most abundant testacea in this vicinity, the exogyræ the next, and Belemnites americanus the next most abundant.

† This jaw has been described in the Annals of the Lyceum of New-York, by Dr. J. E. De Kay.

conglomerate and gravel strata, which form the *underlying* mass; and the quaternary, or the drift deposits, as the next *overlying* mass.*

As the marls of New-Jersey are of great agricultural value, it was considered desirable to ascertain their existence or absence in New-York. The geological limits between which this marl formation might be expected, have been examined with some care, but no marls like those of New-Jersey have been found. A stratum of greenish loamy sand and loamy clay has been found in several localities; one on Lloyd's neck, others on Eaton's neck, East neck, etc., containing some green granules like the New-Jersey green marl, and in the proper geological position; but no marls like the proper green and blue marls, the grey or black marls, have been discovered, and no fossil remains.

The fossil shells that have been so often found by persons in digging wells, seem to have been in the proper position for marl deposits, namely, below the drift, and either in or above the sands and clays, etc. that have been described in this article; but none have been seen by any one able to identify them generically and specifically, so as to determine the formation in which they are found.

Springs.

Springs in great numbers break out from the gravel and sand banks of the formation under consideration, at the levels of tide water, and of the clay beds in certain places. They have already been alluded to in general terms.† They are caused by the surface water percolating through the pervious strata of sand and gravel, until they meet an impervious layer, generally clay, or the tide water level; and they find an outlet in the sides and heads of the ravines, and along the coasts.

Localities of the principal springs of this formation.

A fine and copious spring rises through the sand near the shore a mile or two west of Montauk point, on the north shore. It might be made available for furnishing water for vessels.

In Southampton, on the road from Sag-Harbor to Northsea, a mill is supplied with water by springs that flow from the gravel banks near it.

At the head of Little-neck bay in Flushing, many fine springs flow from the gravel beds in the ravine, and are used for milling.

Springs flow abundantly from the level of a little above tide water, at Old Man's, Drowned meadows, Setauket, Stony brook, Hempstead harbor at the head and on the west shore, Cow bay at the head and at several places on the east side, Coldspring harbor, northwest part of Eastneck, heads of Cow harbor and Little Cow harbor, and head of Freshpond creek.

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* As boulders and erratic blocks are not deposited over the marl region of New-Jersey, (for reasons assigned in discussing the drift deposits), we cannot tell certainly whether the drift is the next overlying mass; but it probably is, for the strata presently to be mentioned, containing green grains, underlie the drift deposits.

† Vide p. 108 of this volume.

The springs at the head and on the east side of Hempstead harbor, southwest of Oyster-bay harbor, head and east side of Cow bay, head of Coldspring harbor, Glen cove, Centreport, Northport, Setauket harbor, and many others that might be designated, are dammed up, either by running a dam across the ravine, or along the edge of the bank where they break out. Ponds are thus formed that have no *apparent* source of supply, but which drive mills more or less constantly. They are of very great importance, as yielding a source of motive power, where the population would otherwise be dependent on steam or animal power to drive machinery, which are expensive; or be dependent on windmills which cannot be relied on, permanently, or even at regular *periods* of time.

The reader, by referring to the map of Long island (vide Plate 1), will observe that the localities of nearly all these groups of copious springs are either at the heads of the bays and reëntering of the coast, or in the valleys prolonged beyond the heads of the bays, or at the heads of the small bays and marshes branching from the main bays. If the stratum of clay, that is generally the water-bearing stratum, be supposed perfectly horizontal, the flow of water would necessarily be greater in the situations indicated, than on the coast generally, or on the lateral shores of the bays; but we know the strata are more or less undulating, and it is believed that the evidences observed are sufficient to indicate depressions of the water-bearing and other strata in the valleys of the reëntering of the north coast.

Valleys of Long Island.

The general topographical features of Long island have already been indicated in a general way, the main features of which are, a range of hills extending from the western to the eastern extremity of the island, and occupying most of the northern half; and a nearly level plain, slightly undulating, with a very small declivity, extending from the southern base of the hills to the south shore. The careful observer will also have noticed, that there are valleys through the hills, from the heads of nearly all the bays on the north coast, which also extend southwards across the south plain to the south shore. The surveys for the Long island railroad have shown that no location can be selected so as to avoid crossing these valleys; but in all cases it has been necessary to construct embankments across them, to obtain a level grade for the road. They have the appearance of channels through which the water has flowed in tidal or other currents, before the emergence of the land from the ocean, and have either been excavated since the deposition of the strata, or else the currents setting through these channels prevented the deposition of as much earthy matter as in other adjacent parts. The evidence preponderates in favor of the latter supposition, and that the same general cause has acted during the deposition of the various strata, from the lowest of these depositions that have come under observation, through the drift and quaternary periods, until the island emerged from the waters of the ocean, so that currents no longer flow across it. This shows an obvious reason *why such quantities of spring waters flow from particular localities*. On the *south* shore of the island, the same cause does not act. There the quaternary strata are all

pervious sands and gravel, and the springs flow from about tide-water level, or a few feet above, and are very uniformly distributed along the coast. The sides of these valleys are almost all gravelly and pebbly, and the bottoms the same; except that in the hilly ranges, they are frequently loam or clay, covered by superficial beds of sand and gravel.

Disturbance of the strata since their deposition.

Few examples have been observed of disturbance of the strata under consideration, that cannot be accounted for by the action of alluvial causes, as slides, and the wrinkling of strata produced by the lateral pressure of slides. Fig. 12, Plate 4, may, like fig. 9, be attributed to a recent slip producing a fault. In figs. 4, 5, 6, 7 and 11, the period of disturbance must have preceded the period of the deposition of the drift deposits, for the disturbed strata seem to have been denuded previous to the deposition of the unconformable strata. Figs. 4, 5, 6, 11 and 15 might be attributed to the effects of slips, and the lateral force of slips, between the period of their deposition and that of the drift; and figs. 4, 5, 6, 7 and 15, to the period before the deposition of the blue clay with iron crusts, which preceded the drift epoch. Fig. 7 seems to be the result of a force acting from below, or a lateral force on a larger scale than that affecting the others, and at the same period as the last.

At the localities of figs. 10, 13 and 16, no data are afforded to estimate whether the disturbance was at the same *time* as the preceding; but the strata show that it was during the same epoch, between the deposition of similar strata. The disturbance indicated on fig. 8 was probably effected at the same period as that of figs. 4, 5, 6, 7 and 16, as the same strata are affected, and the locality is near those of the figures last mentioned.

CONSIDERATION OF THE EQUIVALENCY, AND OF THE PHYSICAL CAUSES OF THIS FORMATION.

1. *Equivalency of the Long-island Division.*

It will be seen by referring to what precedes,

1. That the white, red, mottled, brown and blue clays, and variegated and some other sands of Long and Staten islands, are similar in their general characters, and in their mineral and fossil contents, to certain beds of clays and sands in New-Jersey, and are undoubtedly a continuation of the same formation.

2. Those beds referred to in New-Jersey, have been shown by Dr. Morton, Professor H. D. Rodgers, my own observations and those of others, to belong to the lower part of the cretaceous and greensand formation of New-Jersey, and to underlie the marl deposits of that formation.

3. That some of the sands, loams and clays of Long island, contain a green earthy material and green granules, like some of the beds of the New-Jersey marls, though in comparatively small quantities.

4. That these strata, like those of New-Jersey, Maryland, Delaware and Virginia, *overlie* the mass of strata containing the white, mottled, red, and brown pyritous clays, and the sands containing lignite; and *underlie* the drift and quaternary deposits.

5. That the fossil shells found on Long island, as nearly as can be ascertained from published sections, and from the testimony of those that have found them in excavations, seem to be located beneath the drift deposits, and above the white, variegated and pyritous clays, and sands containing lignite.

It follows from these facts, that the lower part of the Long-island division, embracing the white, mottled, red and pyritous clays, with their associated beds of gravel, conglomerate, and sand containing lignite, are geologically equivalent to the beds in New-Jersey called by Prof. Rodgers the *Potter's clay formation*,* and to the lower division called by others the *Greensand formation*, *Ferruginous sand formation*, *Cretaceous formation*, etc.; and that the overlying loams, and clays containing the green earth, with associated sands, gravel, etc. are equivalent to the green marl deposits, or to the tertiary, or perhaps to both these periods.

The facts now known and published are not sufficient to decide their exact equivalency, but it is probable that these deposits, and those containing the shells, belong to both the green marl and tertiary epochs.

Fig. 7, Plate 4, and some others that have already been mentioned, show two distinct epochs of deposition in these strata below the drift deposits.

2. *Physical causes of this formation.*

Origin of the materials. It is universally admitted that the materials of the sedimentary strata, among which those of the formation under consideration may be classed, are derived from the disintegration, decomposition and abrasion of older rocks, and from animal and vegetable secretion.

It is also well known to those who have investigated the geology of the Southern and Middle Atlantic States, that there is a long and broad belt of primary rocks, extending nearly parallel to the primary Atlantic chain of mountains, but some distance from it, that are remarkably prone to disintegration and decomposition, from Georgia to Maryland. They reäppear; or rocks somewhat similar, and also prone to rapid disintegration, emerge in the southeast part of Connecticut, extend across Rhode-Island, and probably across Massachusetts under more recent rocks. These rocks are various in character, composed of granite, gneiss, hornblendic and talcose rocks. The materials resulting from their decomposition and disintegration are extremely various in their aspect and composition. Red, green and yellow are common colors of the sands, loams and clays. I have seen decomposing and disintegrating rocks in North-Carolina, between Hillsborough and Charlotte, producing a material which bears a striking

* Geological Report of New-Jersey, 1840, p. 170.

resemblance to the green marls of Virginia, Maryland, Delaware and New-Jersey. Most travellers through that region, and from the gold region to Baltimore, who have noticed the mineral characters of the tertiary and newer secondary formations, can scarcely have failed to see the striking similarity of many of them to the recent wrecks of those disintegrating rocks.

Physical causes of transport. It has been shown in the chapter on the drift deposits, that a current has, in all former time since the ocean has been in its bed, and the general form of the American coast similar in its general features to the present, flowed from the Gulf of Mexico to the northward along the eastern coast; and also that a current has flowed from the north towards the south. These currents, now under consideration, as tending to influence the transportation of materials beneath the level of the ocean, are local examples of parts of the equatorial and polar currents. These currents, in consequence of dynamical laws that have been explained under Drift deposits, are as permanent as the rotation of the earth on its axis, and the existence of the ocean. The eastern part of the United States, on which the upper secondary strata are deposited, bear incontestible evidences of having been covered by the waters of the ocean at the time of the deposition of those strata.

The materials of the depositions now under consideration, bear evidences of transportation from a southwestwardly direction (except Long island, the reasons for which will be attempted to be shown in another place). The current of the Gulf stream, which is the name of a branch of the equatorial current at the present time, is believed sufficient to transport most of the materials of the strata under discussion, except where there are evidences of local causes for coarser deposits.*

Why marls and fossils are not common on Long island. The question may here be asked, if the deposits below the drift of Long island are equivalent to those of New-Jersey, &c., why do we not find the marls and fossils there?

It has been shown in the article on the drift, that a branch of the Polar current has flowed at the drift epoch, and probably from a very early period of geological chronology, (as facts yet to be adduced will show,) through the Champlain and Hudson valley. This current meeting the Gulf stream in New-Jersey, would tend to check its velocity, and cause depositions of the matter it was transporting; and the northern current being colder would neces-

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* TABLE SHOWING THE TRANSPORTING POWER OF CURRENTS.

Power of Transportation.	Velocity of Currents.	
	Inches per second.	Miles per hour.
Wears away fine compact tough clay,	3	0·17
Removes fine sand,	6	0·34
Removes sand as coarse as flaxseed,	8	0·45
Removes fine gravel,	12	0·68
Removes pebbles an inch in diameter,	24	1·36
Removes angular fragments two and three inches in diameter,	36	2·04

sarily in part flow beneath, and cut off the further transportation of much of the sedimentary matter in that direction. Eddies, or the still water between the currents, would keep drift-wood and plants floated from the south, within long, narrow, or moderate sized circular areas, until waterlogged so as to sink. The cold currents from the north, occupying the bottom to the east and northeast, would not be as favorable to the development of organic life, as the warm waters from the south were, before meeting the cold waters from the north.

These consequences seem to flow necessarily from the permanent physical causes that have been mentioned, and that continued to act as long as a large portion of North America was beneath the waters of the ocean; and there are indubitable evidences that it continued in this state until after the deposition of the strata under consideration, from the earliest periods of geological chronology.* The same causes that have produced the transport of the depositions of the marl and cretaceous and the red sandstone periods of the Atlantic States, seem to have acted in a similar manner through the extensive region east of the Rocky mountains, in the deposition of strata of similar characters, age and fossils. Such formations have been seen and more or less described by Lewis and Clark, Maj. Long, Dr. Pitcher, Mr. Nicollai and myself.†

Mr. Conrad, who has examined this formation with some care in the Southern States, Virginia, Carolinas, Georgia and Alabama, says:

"This widely extended series was first referred to the chalk of Europe by Vanuxem and Morton, and the latter author has amply illustrated the organic remains. He divides the system into three sections; upper, middle and lower. The latter consists chiefly of greensand in New-Jersey and Delaware, and in limited localities in Maryland, South-Carolina and Georgia; but it is generally an impure limestone in the Southern States, with the same organic remains as those of the greensand. It is the substratum of all the prairie land of

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* The alternate deposition of land plants and marine depositions, which have been heretofore attributed to alternate elevation above, and depression beneath the waters of the ocean, will be shown to be capable of a satisfactory explanation on other grounds, when we come to treat of such formations.

† The fossils of the cretaceous deposits of that part of the country may now be seen in some of the public collections. Many geologists have seen the Ammonites and Baculites collected by Dr. Pitcher. The Baculites of the Missouri, collected by Mr. Nicollai, are very beautiful; and he exhibited a suite of the fossils before the Second Meeting of the Association of American Geologists, that left no doubt in the minds of the most skeptical, of the existence of such a formation there. I have examined the same formation on the waters of Red river, twelve hundred miles by water above its mouth, in the Choctaw country, where the calcareous part of the formation is a solid limestone in the vicinity of Fort Towson, underlying the prairies, which, in many places show the naked rock in horizontal strata, filled with the *Gryphæa vomer*, bushels of which may be picked up entire in some parts of the prairies, where the rock has been disintegrated and crumbled by atmospheric agencies. A more compact stratum lies below, containing Pectens, a long turriculated univalve, and a species of Scalaria, believed to be the *S. sillimani*. This formation is overlaid in many places, by a series of sand deposits; and one is here strongly reminded of the sandy pine country between New-York and Philadelphia, by the general features of the country, the sand plains and hills, the timber growth, and the small streams of clear water, so different from the turbid and milky creek and even spring waters of most of the southern and southwestern country. Similar fossils occur in the prairies some distance to the west of Fort Gibson. A fine Baculite from that region was presented to me as a petrified *chicken's neck*.

Alabama. Here we behold a new creation of genera of shells, saurians and fishes. The genera Baculites, Hamites, Crioceratites, Cirrolites (nob.), Scaphites, all cephalopodous univalves, appear for the first time in the cretaceous series. Dr. Morton has referred this division to the greensand of Europe; and indicates one shell as identical with a British species (*Pecten quinquecostatus*), which occurs both in chalk and greensand. The following fossils I believe to be common to the European and American lower cretaceous strata:

Shells.

1. Pecten quinquecostatus. Chalk and greensand.
2. Ostrea vesicularis. Chalk.
3. — falcata (O. larva, Nillson.)
4. Gryphæa vomer (Ostrea lateralis, Nillson). Chalk.
5. Trigonia aliformis (T. thoracica, Morton). Greensand.
6. Ammonites conradi (A. sussexiensis, Mantell). Chalk marl.
7. Nautilus expansus (N. dekayi, Morton). Chalk marl.

Fishes.

8. Galeus pristodontus. Chalk.
9. Lamna acuminata. Chalk.
10. — mantelli. Chalk.

Saurians.

11. Mosasaurus. Maestricht strata.

"The middle division of this system was first discovered and described by Dr. Morton. It consists of grey marl, alternating with a limestone which appears to be of a kind of oolitic or granular texture; but when examined with a glass, this structure is found to be due to innumerable minute nummulites and small corallines. A band of this limestone runs through the greensand district of southern New-Jersey, from New-Egypt to Salem. It contains several of the fossils of the lower division, but others which are peculiar to it. It is remarkable that no trace of ammonites has been discovered in this limestone, the greensand seeming to be the highest limit of the genus. I discovered this formation at Wilmington in North-Carolina.

"The upper division of the cretaceous system is composed of a chalky limestone, which I was the first to trace in the Southern States, and to collect the group of its organic remains which have been described by Dr. Morton. These as a group, were ascertained to be unlike any observed in Europe, and to point to a passage or connecting link between secondary and tertiary deposits. The only extinct genus of shells found in it is *Plagiostoma;* but not one recent species occurs, and which are found in the overlying lower tertiary strata. This limestone contains those numerous vertebræ of the *Zeuglodon* (*Basilosaurus*, Harlan), which are not uncommon in Alabama, and characterize the formation. This division occupies a portion of South-Carolina, near the seaboard, and of Georgia south of Augusta, but its great deve-

lopment is in the southern counties of Alabama and in Florida. There is a belt of prairie land passes through central Alabama, based on the lower division or greensand; and where this terminates on the south, the upper cretaceous limestone commences, and is continued through Florida nearly to the Gulf of Mexico.

"*Tertiary Formations*. In some places, the greensand derived from the cretaceous strata enters largely into the composition of the lower tertiary marls. In Georgia, and more rarely in Alabama, a portion of the formation assumes the character of burrstone, and the shells which abound in it are beautifully silicified. Near Fort Washington, on the Potomac river, the lower tertiary is very similar in aspect to the Bognor rocks of Great Britain, and contains the *Panopea* (*Mya*) *intermedia* and *Ostrea bellovicina* of that locality. In this formation we meet with the first creation of testacea which have a near resemblance to recent shells; but yet in this country, all the species appear to be distinct from existing types. But two or three genera among the minute shells occur, which are unknown in a recent state. A very interesting section of the lower tertiary is presented at Claiborne, Alabama; where I collected about two hundred species of shells and corallines, many of which are identical with Eocene species of Europe. Among these are Cardita planicosta, Corbis lamellosa, Cytherea erycinoides, Bulimus terebellatus, Pyrula tricarinatá, Solarium patulum, &c.

"*Medial Tertiary*. An extensive formation of sand and clay, abounding in finely preserved shells, follows the preceding strata in the ascending order, and contains only one species which is not widely different from the fossils of the latter formation. There are about one hundred and seventy species at present collected; and of these I have ascertained about twenty-three to be recent, nearly all of which inhabit the Atlantic coast and that of the Gulf of Mexico. Whatever the percentage of recent species may ultimately prove to be, I have no doubt the period of this formation was contemporaneous with that of the Older Pliocene strata of Europe; a belief founded on the great similarity of their respective groups of shells, and remote analogy of the American group to the Miocene of Europe, which, I have long believed, has no representative in North America, at least among the known tertiary deposits. The medial tertiary formation occurs along the Atlantic border from New-Jersey inclusive, to the Santee river in South Carolina.

"*Upper Tertiary*. This group of fossils is found in Maryland, Virginia and North-Carolina, in the same tract with the preceding, but is not so extensively distributed. Very few of the species of the medial tertiary occur, but the mass consists chiefly of recent shells, many of which inhabit the same parallels of latitude on the Atlantic coast of the Union, and the others chiefly the southern coast. There are, however, enough extinct species to bring the group within the limits of the Newer Pliocene."*

Of the influence of the *northern* current in giving an *arctic* character to the shells, the following observations of Mr. Conrad and Mr. Lyell may be adduced on the quaternary formations:

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* Geological Report of New-York for 1841, pp. 44, 47.

"*Post Tertiary.* By this term, Mr. Lyell designates a group of organic remains which not only embraces a less percentage of extinct species than the Newer Pliocene, but they are of a more *arctic* character than the recent group of the same parallels of latitude. In this series must be included the tertiary deposits on the borders of Lake Champlain, described by Professor Emmons; as they are identical with those of the St. Lawrence, described by Capt. Bayfield, and which Lyell refers to his Post Tertiary. The shells of the St. Lawrence are the same with those of the Champlain beds; and not only so, but Lyell has found them to be nearly all the same with the post-tertiary species of Scotland, Denmark, Norway and Sweden, and there is less than one per cent of species unknown in a living state."*

II. TRAPPEAN DIVISION.

Extent of these Rocks.

These rocks in New-York, except dykes and those classed among primary rocks, are entirely confined to Rockland and Richmond counties. They exhibit a bold rocky bluff along the right bank of the Hudson, from near Haverstraw to the New-Jersey line; and thence it extends in an uninterrupted ridge, with a rude columnar front called the Palisades, to near Hoboken, opposite the city of New-York. There are several parallel ranges more or less interrupted in New-Jersey; and like those of Rockland county, some of them are more or less curved and hook-shaped. The same rocks are found connected with the red sandstone formation in Pennsylvania, Virginia, Maryland, and North-Carolina to the south-southwest; and with those of Connecticut, Massachusetts, and Nova-Scotia on the northeast; and in the plains east of the Rocky mountains, described by Long and others; those of the Polar circle, between McKenzie's river and Cape Turnagain;† and on the south coast of Lake Superior.

The trap region of Rockland county occupies much less of the surface of this county than one would suppose in passing along the Hudson river. It forms a narrow belt on the shore of the Hudson, from the New-Jersey line to near Haverstraw, where it ranges off to the northwest and then west, and finally southwest near the base of the Highlands, where it disappears. A branch of it strikes off about two miles north of Nyack in a westerly direction, and extends, with perhaps some interruptions, to near the Highlands. These ranges of trap rock are narrow, from one-fourth to one mile, and in some places perhaps one and a half to two miles broad. Along the Hudson, and on the north front of the range extending west from Haverstraw, the trap rock forms high mural columnar escarpments, of three hundred to eight hundred feet in height, with a steep slope of debris, which have been crumbled off from the cliffs

* Geological Report of New-York for 1841, p. 47.

† American Journal of Science, Vol. 17, pp. 1, 10.

above by the action of the weather and the frost. On the western and southern sides of this range, the trap rock generally slopes off more gradually, but in a few places it is precipitous. It can scarcely be considered otherwise than an enormous projecting trap dyke. Dykes were observed in several places cutting through the sandstone, some of which were very large. Occasionally it was seen spreading laterally from the dykes between the strata of sandstone.

There are several places where valleys pass through the trap range above described, but it is believed there are none where this rock is discontinued. The valley west of Nyack, and that at Tappan, are perhaps the lowest, but even here the trap is seen at the bottom of the valleys.

The trap rocks at Rockland and Richmond counties vary in mineralogical character, from coarse crystalline to a perfectly compact greenstone, and from a slaty clinkstone to a coarse amygdaloid. The steep escarpments along the shore of the Hudson present a rude columnar aspect, without having any regular columnar forms. These cliffs have long been called the Palisades, a name which most persons will acknowledge is appropriate.

On the west bank of the Hudson, the general aspect is extremely forbidding to the agriculturalist; being naked precipitous rocks, with a stinted growth of forest trees on the thin soil on the summit, and among the broken debris that form a steep slope at the base of the cliffs. Where the slopes are gentle, the soil is rich and productive. On the western and southern side of the trappean range, the slope is not precipitous as it is on the east and north, but generally slopes off by a gentle descent. In the southeastern part of Rockland county, Tappan creek flows through a gorge, or *clove*, as it is called, in the trappean range; and this is the only place a stream crosses this range, except a branch of the Sampsondale creek flowing north and entering the Hudson at Grassy point.

The sandstone was not observed by Mr. Cassels, who examined along the gorge of the Tappan creek, but the trap rock shows itself down to near the level of tide water. At Lord and Blauvelt's quarry, two and a half miles north of that gorge, Mr. Cassels observed some "crystals of carbonate of lime of a deep red color," in a reddish grey sandstone, "that seems to have been subjected to a high heat" by the influence of trap rocks. From Tappan creek, the trap range does not present a mural castellated front like the Palisades between that point and Hoboken; but it forms a more gentle swell, in some places steep, but generally with a moderate acclivity, extending back one to two miles from the shore, with the red sandstone exposed in numerous quarries and in the small ravines, to about two miles north of Nyack, where the trap ranges to the northeast to Verdrietige hook.*

The trappean range on the Hudson gradually increases in height above tide-water level, from Bergen point, to the northern termination of Closter mountain, in the southeast corner of Rockland county, where, on the line between New-York and New-Jersey, the height

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* { *Verdrietige* of Burr's Map of Rockland and Orange counties;
Vredideka of Ackerly's Geology and Goodrich's Map of the Hudson;
Kedidika of Pierce. (Vide American Journal of Science, Vol. 2, p. 186.)

is five hnndred and thirty-nine feet.* From Tappan slote, near the New-Jersey line, the height of the trappean hills is less across Orangetown and the southern part of Clarkstown to two miles north of Nyack, where it sweeps around to the northeast to the Hudson, at the north end of Tappan bay; and it forms a bold mural escarpment on the shore at Verdrietige hook, the southern knob of which is six hundred and sixty-eight feet, and the north peak is six hundred and forty feet above tide water of the Hudson. The Verdrietige-hook range sweeps then around to the northwest, along the shore of Haverstraw bay, to within about two miles of Haverstraw, where a deep valley, called the Long clove, presents a passage for a road between that and the high peak called the High Torn, the highest point of the range. This is elevated eight hundred and fifty feet, according to Capt. Partridge's measurement.† From the High Torn, the range is very broken in its outline, consisting of very craggy masses of the trappean rock, but all connected, sweeping west in its general trend to the Little Torn, and thence southwest until it nearly unites with the Highland range of mountains. From the High Torn, the general height of the summits continually diminishes to the west and southwest, until it becomes merged in and below the red sandstone level, along the base of the Highlands, two or three miles southwest of Laden's, called Ladenton on the map.‡ Between Long clove and the High Torn, is another valley, through which a road is made. It is called the Short clove.

Rockland lake, a beautiful sheet of water, is situated half a mile west of the Hudson, and south of the Long clove. The Verdrietige-hook range of trap rock intervenes between it and the Hudson, and the lake is skirted on its northeast shore by that rock. The ridge of trap between the lake and Hudson river, is six hundred and forty feet above tide water. The lake is one hundred and fifty feet above the level of the Hudson river. "No stream of magnitude is seen to enter the lake, but it is the source of one of the most considerable branches of the Hackensack. Fed from below by mountain springs, it retains a greater uniformity of temperature than is observed in ponds formed by the expansion of a river in a valley, and remains unfrozen after the North river is closed; this must be attributed to its great depth, and the warmth of its auxiliary streams" (springs). §

"The waters of the lake are soft and pure; and as they repose on a sandy bottom, no water weeds or swamps are seen on its borders, except at the river's outlet. The adjacent inhabitants are not subject to the fevers and early fogs of autumn; the waters of the lake remaining colder than the air, morning exhalations do not arise to be condensed. The elevation

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* The following intermediate heights are taken from the geological section of the Hudson, by Mr Ackerly, which I copied many years ago. I regret that I have not the book, that I might draw from his observations, and give him credit for his labors.

	FEET.		FEET.
1. Fort Lee,	311	4. Bluff north of 3,	479
2. Lydicher's bluff,	378	5. Pompey's hook,	517
3. Bluff opposite Spuytenduyvel creek	407	6. Bluff north of 5,	549

† Pierce on the Geology of New-York and New-Jersey. (American Journal of Science, Vol. 2, p. 186.)

‡ Burr's County Map.

§ Pierce on the Geology of New-York and New-Jersey. (American Journal of Science, Vol. 2, p. 187.)

of Kedidica hook* is well calculated for geological and geographical survey, uniting extension with distinctness of view. The wood-clad highland chain is observed ranging the horizon for fifty miles; its course is from northeast to southwest; the Newark and Pracknes mountains faintly appear to the southwest. The Haverstraw mountain† is near you, with its camel's back summit running westwardly; to the south the Palisadoes are seen."‡

The trappean range that disappears beneath tide water at Bergen point, the southern extremity of the visible exposure of the Palisado range, reäppears in a prolongation of the direction of that range on Staten island. It is a smooth, round-backed ridge or gentle swell of land parallel to the serpentine ridge, and is mostly covered with soil. It is elevated in its highest part one hundred and fifty or perhaps two hundred feet above tide water. It disappears to the west of Richmond, beneath the Freshkill marshes, and is not known to reäppear farther south on the island. The locality where I saw it best exposed, was at a quarry that has been called a granite quarry, the rock of which was described in the papers of the day as granite. It is a coarsely crystalline greenstone; and though more difficult to dress than most cut stone, it is a beautiful and durable building material. The surface of the rock under the soil is smoothed, as if ground off by the cause that has produced the scratched surfaces of rocks. A set of fissures nearly vertical and ranging about N. 20° E., and another parallel to the contour of the hill, traverse the rock, dividing it into flat masses, that may be blocked up by the quarrymen with much less labor and expense than they could be without these joints. The north and south vertical fissures are not as continuous or distinct as the horizontal ones; and these latter give the rock an appearance of indistinct stratification, with layers three or four feet thick.

Near the southeast corner of Rockland county, a valley through the mural front of the trap rocks gives a passage for a road at Dobbs' ferry. On the shore below the trap escarpments, trappean injections seem to have been made between some of the strata of sandstone, which have materially modified their color and texture, and almost changed their nature. Many of the strata, of a deep red color, seemed to be a modified trap, composed mostly of the finer materials of the sandstone, partially melted, and more or less amygdaloidal, with cavities which are either lined with crystals or filled with chlorophæite. This altered rock is sometimes light red, deep red, purple, brown and black. Scales of micaceous oxide of iron were common in some places in these altered rocks. The sandstone dips west, northwest and southwest, at very small angles, at different points observed between the New-Jersey line and Tappan creek.

The trap rocks on the shore of the Hudson, about two miles north of Nyack, stand in rude semi-columnar masses, with a nearly vertical escarpment, often like castellated ruins. The sandstone is frequently seen on the shore, underlying the trap. It is slightly inclined, dipping a few degrees in a westwardly direction. Some places were seen where we could trace within a foot or two of the actual contact of the trap and sandstone. The latter, near

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* Same as Verdrietige hook.

† The trappean range from the High Torn west and southwest.

‡ PIERCE. American Journal of Science, Vol. 2, pp. 187–8.

the point of contact, is much modified in texture, like that described between the New-Jersey line and the mouth of Tappan creek.

Two places on the shore, near Verdrietige hook, shewed appearances of enormous dykes of trap penetrating through the sandstone, from two hundred to six hundred feet wide. They are either dykes, or else double faults concur to produce the same appearances; for the trap breaks suddenly from the sandstone above, and comes down to the water on both sides, as represented on Plate 5, fig. 4.

Near the same place, or within a mile south, trap has penetrated laterally between the sandstone, and has altered very much the characters of the rock. Some of the sandstone is almost as hard and compact as jasper; some is purplish, red, and very much indurated; some is grey, and filled with vesicular cavities; and the trap itself, in some places, is composed in part of the materials of the sandstone. Some of the trap is amygdaloidal, and contains an abundance of chlorophæite. The layer of trap, and an adjoining one of greyish sandstone, are loaded with scales, and small masses of micaceous and specular oxide of iron.

At another locality about two miles below Haverstraw, on the shore, about a quarter of a mile below a landing, a trap dyke of one foot wide, a fault, and a layer of trap intruded between the strata, were seen. Plate 5, fig. 5, illustrates the phenomena observed at this place.

The contact of the overlying semi-columnar trap with the sandstone was not seen, as it was concealed by a slope of debris, which extended from the base of the escarpment to near where the sandstone was exposed to view on the shore. The upper mass *may* not be connected with this small dyke, though it is probable. The sandstone next the trap of the dyke, is almost like jasper in some places, and blends off into perfect sandstone; in others the rock is porous, as if heated so as to extricate gaseous matter, and blow up bubbles in the half melted rock.

In the town of Ramapo, near the southern extremity of the western hook of this trap range, traces of copper ore were observed in the trap by the road-side, between Ladenton and the outlet of the valley of the Ramapo river, on Smith's clove, from the Highland mountains. On some of the masses of trap, a siliceous coating was covered and colored by the green carbonate and the red oxide of copper. They were traced to their origin near by, where the rock in place shewed seams and cracks presenting similar appearances in abundance, but no veins could be traced. Veins of infiltrated or injected siliceous matter, a quarter of an inch thick, were sometimes seen.

A single nodule of most beautiful agate was found among the debris of the trap ridge, at the above locality. It was coated with the red oxide of copper. The trap was of the compact variety.

Mr. Cassels, one of the assistants, observed one locality where the trap rock next the sandstone had a distinct columnar structure. The locality is stated by Mr. C. to be three miles a little west of north of the New city, in Clarkstown, near one of the places where Levi Smith had quarried a set of furnace hearth-stones, a quarter of a mile west of Richard Coe's quarry. The sandstone is grey.

Origin of Trap Rocks.

It is *now* universally conceded, that the trappean rocks shew in themselves, and in the effects produced by their protrusion between and through the strata of other rocks, undoubted evidences of having been, at the time of their protrusion, in a highly heated state. If the question was still open to discussion, the facts that may be seen by a careful exploration of the shore of the Hudson between Hoboken and Stony point, where trap dykes have cut through the strata, and overflowed on the top; have changed the sandstones and shales into scoriaceous masses, and other forms that have been detailed; have formed crystallized minerals in the cavities, such as would necessarily be formed by a chemical union of the predominating elements of these rocks, as schorl, epidote, etc.;* the sublimation and crystallization of micaceous oxide of iron, and the sulphuret and oxide and carbonate of copper;* the interlamination of injected masses between the strata from the dykes, and that have produced the same effects in the strata contiguous to them, as have been produced on similar strata adjacent to the dykes and to the overflowed masses; would afford a mass of evidence sufficient to convince the mind of those most skeptical on this subject, and demonstrate that the Palisades, and the rest of that range of trappean rocks, are ancient *lavas*, that have flowed through the rocky fissures in dykes, while this part of the continent was still beneath the waters of the ocean.†

The trappean rocks that I have examined in Massachusetts and Connecticut, and that have been described by Profs. Hitchcock and Silliman, and that will be described by Mr. Percival, the Geologist of Connecticut; those of Nova Scotia, described by Messrs. Alger and Jackson; those of Virginia, Pennsylvania and New-Jersey, described by Profs. Rodgers; and those of Lake Superior, described by Lieut. Allen, Dr. Houghton, &c., offer evidences *as* incontestible, of the same origin. It is probable, but yet to be demonstrated, that the trappean rocks of Nova-Scotia, Lake Superior, and east of the Rocky Mountains, and their associated red sandstones and subordinate strata, are all of the same geological epoch, and due to the same general causes as those of Massachusetts, Connecticut, New-York, New-Jersey, Maryland, Virginia and North Carolina.

SERPENTINE ROCKS.

These rocks are classed generally with trappean rocks, and are due to the action of the same general causes modified in some manner unknown to us. They are different in chemical composition and external characters. They are usually associated with trappean or hornblendic rocks. Serpentine rocks occupy an extent of several square miles on Staten island, between New-Brighton, Tompkinsville and Richmond. The highest point of the Serpentine ridge is said to be three hundred and seven feet above tide water.

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* Prof. H. D. RODGERS. Geological Report of New-Jersey, 1840, pp. 150, 154, 155, 157, 161, 162, 164, 165.

† The evidences on the last point, if considered necessary, are yet to be adduced.

The range of serpentine on Staten island is in a prolongation of the direction of that forming the shore of the Hudson between Wehawken and Hoboken; and it is said to form some of the reefs, and the substratum of Ellis island, between Hoboken and Staten island. Serpentine rocks, somewhat dissimilar in mineralogical character, are found in various parts of the First geological district; but as they are associated with trappean and other rocks among those usually classed as *primary*, these examples will be described under the head of Primary rocks.

On Staten island, the serpentine rock assumes a great variety of aspects, from black to nearly white, through various shades of green and yellow, and from compact to earthy. Some of the talcy varieties are called *soapstone*, by the people. Talc, carbonate of magnesia and hydrate of magnesia abound in it, and the rock might be used with profit in making magnesian salts and fire bricks. Asbestus and amianthus are not rare in it. This rock sometimes assumes an aspect almost like trap, but its specific gravity is much less. Some of the rock is much like meerschaum.

Amianthus and asbestus are constant associates of our serpentine rocks; and on Staten island, it is possible that it may be obtained in quantities for useful purposes.

Dr. James Pierce described the amianthus of Staten island in 1818.* He states that "it breaks up like flax, and may be spun and woven without the aid of moisture; and in respect to tenacity, flexibility, and length of fibre, it may be considered the best found in this country, and perhaps equal to any hitherto discovered." Prof. Silliman remarks upon the above, "The specimen of amianthus referred to in Mr. Pierce's communication, is uncommonly beautiful. The fibres measure twelve and fifteen inches in length, and are as soft and flexible as fine human hair."† The value of this material is well known. It has been principally employed in making incombustible cloth for firemen's dresses. It would be more *extensively* useful in making indestructible paper for public records. The amianthus of Staten island is believed to have been used only as mineralogical specimens.

No facts have been observed that lead to a *definite* determination of the epoch of the formation of the serpentine rocks, further than that, like the trap, it preceded the deposition of the drift, as boulders of both are numerous in proportion to the relative areas of these rocks exposed; and that it may be presumed to have been *posterior* to the deposition of the potter's clay formation and the associated gravel beds, as no pebbles of these are remembered to have been observed among those deposits.

Pebbles of serpentine were occasionally seen in the *upper* beds of the Long-island division, *below the drift* deposits. At the time I was investigating the strata of Long-island, the *importance* of such facts in the determination of the eras of the eruption of the trappean rocks, was not impressed on my mind; but it is presumed, that had pebbles of those rocks been abundant, or even sparsely distributed in the pebble beds of the potter's clay formation, they would have been observed, and noted in my diary of geological notes. The facts that *will*

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* American Journal of Science, Vol. 1, p. 54. † Idem, p. 55.

define the geological era of the trappean rocks, can easily be ascertained by those who are favorably located to make the proper observations on Long and Staten islands. It is considered highly probable, from the imperfect observations I have made on this subject, that the trappean rocks were formed at the epoch of the marl and green marl deposits of New-Jersey.

III. RED-SANDSTONE DIVISION.

This division of rocks occurs in the First geologicial district, in Rockland and Richmond counties, associated with and underlying the trappean rocks that have been described. These are parts of the great formation of red sandstone, stretching from Stony point in Rockland county on the north, through New-Jersey, Pennsylvania, Maryland, Virginia, into North-Carolina on the south.

In Richmond county (Staten island), the red sandstone occupies but a small area where it can be observed; but from the observations made by Prof. H. D. Rodgers and myself, it is believed to range from between Bergen point and Shooter's island, south-southwestwardly, to the Freshkill marshes. It is generally covered by soil, drift deposits, and the sand and clay beds. It may be seen at very low tide, on the shore, about southwest of Bergen point. It is the slaty, micaceous, fissile, red sandstone and shale.

The red-sandstone region of Rockland county is a fine agricultural district. The land is in some parts much broken and stony, but in general it is rolling, with a rich sandy loam, resulting from the disintegration of the subjacent sandstone and its associated shales, marls and limestones. The strata are in general slightly inclined one to three degrees to the westward; but near the granitic rocks, near Grassy point, they dip southwardly at a considerable angle, ranging from fifteen to forty-five degrees. This rock occupies that portion of Rockland county from Grassy point along the base of the Highlands to New-Jersey, and eastward to the Hudson river, but a portion of its area is covered over by trap rocks. In color, it varies from chocolate-brown, through brick-red and grey to white; in texture, it varies from pebbly conglomerate, through common sandstone, fissile and micaceous sandstone, to shale; and in composition, from perfectly siliceous, to an argillo-calcareous marl. Where the trappean rocks have cut through these various strata, or have spread laterally between them, their texture and appearance are much modified, and appear to have been subjected to the action of heat, which has partially melted them, or rendered them more compact and hard, like a hard burnt brick, or has made them metalliferous.*

The useful varieties of this rock are the *grey* and *red conglomerate* sandstone, which is used for the hearths of iron furnaces; and the red sandstone, or *freestone*, so extensively used

* Micaceous oxide of iron in small brilliant scales, is not uncommonly diffused through these strata near their junction with trap.

for door-steps, the corners of buildings, and for the caps and sills of windows and doors in brick buildings. Strata of *red argillo-calcareous marl, dove-colored* and *reddish variegated limestone,* and a *reddish calcareous* conglomerate or pudding-stone, are associated as subordinate strata.

Red and Grey Conglomerate.

This rock is found in almost every part of the sandstone region, and many quarries of it have been opened for the purpose of supplying fire-stone for the hearths of iron furnaces. This stone is shipped to various parts of the country for this purpose, and no stone is known superior to it for durability.

Isaac Van Houten's quarry is one and one-fourth of a mile north of the New city. This quarry is the first that was worked for obtaining furnace hearths, and was opened about fifty years ago. It has not been worked during the last thirty years, until 1838. Mr. Joseph Bird has reöpened it, and pays Mr. Van Houten ten dollars rent for every set of furnace hearths he quarries.* The quarry is two and a half miles from the landing; and a set of stones for a furnace hearth delivered there, is worth one hundred dollars. One stratum only is quarried for this purpose, and that is three feet thick. Another stratum above might be used, but it is stated to be too tender. This, and most of the quarries of sandstone, were examined by Prof. Cassels. The stone is very porous, and filled with rounded quartz pebbles. It is tender when first quarried, but becomes harder by exposure to the weather. The furnace men prefer that the stones should "season" one year before they are put into the furnace.

Another quarry, owned by Mr. Cornelius Depew, is about half a mile north of Van Houten's. Here the stone is grey at the surface, but red two feet below, so that the blocks contain both colors. The stone is stronger, finer grained, and not so tender as Van Houten's, but in other respects similar. One stratum only is worked at this quarry. The grandson of Mr. Depew works this quarry, and pays fifteen dollars rent per set of blocks for a hearth. The hearths in the Greenwood, Woodbury, and Coldspring furnaces, in 1838, were from this quarry.

Blauvelt's quarry, three miles northwest of the New city, was worked in 1838 by Isaac Springstein. It is opened near the summit of the hill. The face exposed is about twenty feet high. The uppermost layer is five feet thick. The stone is soft and friable, and is used for furnace hearths, glass works, and for jambs. The proprietor receives thirteen dollars and twenty cents per set.

Another quarry has been opened three miles north of the New city, by Richard Coe. It is the coarse grey sandstone, and near the junction of the trap and sandstone.

Another quarry, one-fourth of a mile west of Coe's quarry, has been opened by Levi Smith. This stone is also the grey sandstone, from near its junction with the trap rock. A locality was observed on the shore two or two and a half miles below Haverstraw, where the conglomerate looks like a good fire-stone. The stratum is four or five feet thick.

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* A common hearth requires fourteen blocks of stone, ten of which contain each about twenty cubic feet, and four each about ten cubic feet; or in the whole, two hundred and forty cubic feet.

Numerous quarries have been opened along the south base of the mountain on each side of the road, among which are those of John Smith, Jacob Green and Jonas Conklin. It is not known how many sets of stones are obtained at these quarries, but the probable receipts are from four thousand to ten thousand dollars per annum.

Red Sandstone or Freestone.

This rock is extensively worked for cut stone, for flagging stone, and rough stone for basements, along the shore of Tappan bay. The shore is skirted by quarries, from two miles below Nyack, to two miles above that place. Some of these quarries have been worked for more than fifty years.

Gesner's quarry is at the ship-yard, about half a mile below Nyack. It is not much worked.

Westervelt's quarry is one mile north of Nyack. It was visited by Mr. Cassels. The flagging stone, one and a half feet wide, and two to three inches thick, are delivered in New York at fifteen cents per foot. Rubblestone of this sandstone sells in New-York for sixty-two and a half cents per cart-load of 15 cwt. The transport costs about one-fifth of this amount. The proprietors receive one-fifth of the proceeds of sales for rent from those who work the quarries. Two thousand feet of slabs, besides rubble, were quarried in 1838.

Clark's quarry is one and a half miles north of Nyack. Specimens of the sandstone of this and several other quarries are in the State Collection.

Wilkins' quarry is one mile south of Nyack. Five thousand to six thousand feet of slabs were quarried here in 1838, and five hundred cart-loads of rubblestone.

The two quarries of Daniel Onderdonk and his brother are near each other, below Nyack. Two thousand five hundred feet of slabs or flags were quarried in 1838 from each.

Richard Clark's quarry is near Onderdonk's.

There are sixteen quarries in operation below, and fifteen above Nyack, within two miles from that place, which will average about two thousand feet of slabs (as Mr. Cassels was informed), and five hundred loads of rubblestones each, per annum.

This would give the product of the thirty-one quarries in the year 1838, as 62,000 feet of slabs, valued at $9,300 00
and 15,500 cart-loads of rubble, at 8,687 50
$18,987 50

It was stated that the annual amount of sales a few years ago was nearly twenty times as much, and this falling off in the business of quarrying has been caused by the general stagnation of business consequent upon the embarrassment of the currency. This stone is good for many purposes, but it is not as durable or strong as many others, and is being gradually replaced in the market by stones which are harder to dress, but which will endure the vicissitudes of our changeable climate for a longer time.

Red Marl.

This material is found in many places in the red-sandstone region. It seems to be a variety of the sandstone formation, where the materials are so fine as to form a shale, and where it contains calcareous matter. It was observed in abundance in the high precipitous banks of the Minishecongo creek, in Haverstraw, two miles west of Grassy point, near Capt. De Camp's house. It may be used as a marl, for which it seems well adapted. It is interstratified with sandstone, shale and grey compact limestone, but gradually crumbles by exposure to the weather.

Compact Grey Limestone.

Strata of this rock, of a grey or reddish or dove-color, are interstratified with the red sandstone, shale and marl. The beds are from one to six or eight feet thick, and some of the layers are two feet thick, of perfectly compact homogeneous limestone, which is admirably adapted for a building material. It burns to good lime, and some of it would make beautiful dove-colored and reddish variegated marbles. Blocks of this stone of a suitable size for sawing can be easily procured.

Red Conglomerate Limestone.

This rock occurs at or near the junction of the red-sandstone formation with the primitive rocks. It is composed mostly of pebbles and angular fragments of grey and black limestone (like the adjacent limestone), mixed with pebbles of quartz, granite, gneiss, hornblende, sienite, etc., and all cemented together by a reddish argillo-calcareous paste, mixed with gravel and sand of the various materials mentioned. Although examination was made to discover localities where this rock could be wrought as a marble, none could be found which did not contain an admixture of some other rocks than limestone. It contains fragments of rocks harder than limestone, which would render it difficult to saw and polish. In its general aspect it is similar to the Potomac marble.

These three last rocks, red marl, grey compact limestone, and red calcareous conglomerate, are among the last formed rocks of the Red-sandstone division; and they seem to be located mostly along the boundary of the formation, and to have been formed of the fragments of its own and the adjacent rocks, ground up more or less by attrition and abrasion. Neither the calcareous conglomerate, nor the compact dove-colored and red mottled limestones, were found except in the vicinity of beds of a imestone of more ancient date* than the red-sandstone formation, and near the ancient shore on which the attrition may have been effected.†

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* This limestone is in many places a metamorphic rock, and would, without examination, be pronounced a primary rock; but it is equivalent to the calciferous sandstone of the Taghkanic system, and Formation No. 2 of Prof. Rodgers (the blue or Kittatinny limestone), the Barnegat limestone, &c. of the Geological Reports.

† It is yet to be shewn in the proper place, that the strata of the Highland ranges, (a part of which form the ancient shore of the Red-sandstone division), were elevated into their present highly inclined position *after* the deposition of the *Taghkanic system*, but *preceding* that of the *New-York system*, and long preceding the red-sandstone era.

The dykes of trap rocks filling the rents of the red-sandstone division, and the effects produced in these rocks by such causes, have already been described.

No fossil remains have been observed in the red sandstone of Rockland and Richmond counties, except some obscure fucoids, during the examinations I have made of those rocks. The impression of a fern is said to have been found at Belleville, and also the tooth of the Maestricht animal; and in the sandstone quarries at Nyack, the bones of small animals like squirrels and sheep, are stated to have been found in loam beneath twelve feet of sandstone, and four feet of earth overlying sandstone.*

Considerations on the Causes of this Formation.

It has already been stated, that the red-sandstone formation under consideration extends from Stony point on the Hudson, across New-Jersey, Pennsylvania, Maryland and Virginia, into North-Carolina. It has been observed that the strata dip slightly to the northwest, sometimes as much as fifteen degrees; produced, not by any uplifting agency since the deposition of the strata, "but assumed originally at the time of their deposition, in consequence of the setting of the current from the opposite or southeastern shore."†

Prof. Rodgers supposes "that these materials were deposited by an extensive ancient river, having its source in the Southern States, and its estuary in the region of the Raritan and the Hudson, and having its course for the most part southeast of the chain of the Blue ridge and the Highlands. Several important facts connected with this trough, such as its present *configuration*, the uniform dip and direction of its slightly inclined beds, implying a steady current; their singular constancy of character, so indicative of one general source for the whole; and the obvious identity of their materials with the soils *now* furnished by the ancient rocks from whence we would derive these deposits, all go to confirm the above supposition.

"When the details of the geological surveys of Pennsylvania, Maryland and Virginia, now approaching to completion, shall have been united with the delineations herein given of this interesting group of rocks, the long and narrow tract which they occupy will be seen to possess in a striking degree the features of a noble river, taking its rise in the primary region of the Southern States, and meeting the ocean probably at and beyond the outlets of the Raritan and the Hudson.

"The traveller passing along the red sandstone belt from the Hudson to the northern confines of North Carolina, will, if his mind be directed to these considerations, become early impressed with the accordant nature of the evidence which accumulates as he advances. In commencing his journey, he will see the whole formation occurring in part still beneath, in part above the present level of the ocean. Passing the Raritan, where for a certain distance the tide washes a portion of it, he will next find it on the Delaware, elevated above the ocean

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* Dr. S. J. Mitchell's Lecture before the Newark Mechanic's Association in 1828.

† Prof. Rodgers. Geological Report of New-Jersey, 1840, p. 115.

level throughout its entire width from Trenton to Durham. Advancing to the Schuylkill between Norristown and Reading, he will observe its height above the tide to have augmented; and crossing thence in succession the Susquehannah, the Potomac and the James rivers, he will perceive the tract still gradually and uniformly to ascend, until it attains a level of several hundred feet above the sea, marking an inclination nearly corresponding to that which belongs to many of our large rivers now descending from the Appalachian chain into the ocean.

"The progressive diminution in the breadth of the formation is strictly in accordance with these facts. At the Delaware, adjacent to the presumed ancient estuary or mouth of this supposed stream, the width of the deposit amounts to *thirty* miles; at the Susquehannah, to about *twelve;* at the Potomac, to between six and eight; and at the James river, to not more than *four* miles.

"It may be objected to the argument above advanced touching the regular and gentle ascent of the formation towards the southwest, that the existing slopes of the whole district southeast of the mountains may have been produced during the elevation of the greensand and tertiary strata, at periods subsequent to that which witnessed the drainage of the red sandstone valley.

"Did the scope of the present treatise authorize the detailed discussion of this curious point, we think that a comprehensive investigation of the existing levels of the respective tracts, or, in other words, the *relief* above the ocean of the several parallel belts of country conceived to have successively emerged from beneath the sea, would go far to convince us that the channel which received the red shale deposits possessed to a considerable degree at least its present gentle slope towards the northeast, *during the epoch of its formation*, which was apparently soon after the cessation of those disturbances which finally elevated the coal.

"Let it be observed that the Kittatinny valley, formed of rocks uplifted at the close of the older secondary or Appalachian epoch, has the same regular and gradual declension in level from the interior of Virginia to the Hudson which we find in the red sandstone belt of the parallel valley southeast of it. From an elevation in the vicinity of the New river, approaching one thousand feet above the level of the sea, it slowly descends northeastward, until at the Hudson its general surface rises not more than one hundred feet above the tide. While this is true of the plains occupied by the *older* and *middle secondary rocks*, no such variation in the level of the more recently lifted *tertiary* plain along the sea-board is discernible. From the Roanoke to the Delaware, the tide every where penetrates this latter, and its surface in that distance does not descend probably more than one hundred feet. It seems, therefore, altogether improbable that the whole of the northeastward descent in the first two valleys, that northwest and that southeast of the Blue ridge chain, should have been acquired at the time of the elevation of the tertiary, or at any period later than that of the final drainage of the middle secondary trough. The disturbances of level which took place at the close of the *newer secondary* or greensand period are still further in favor of the same conclusion; for, while the strata of that date were raised to a moderate height, averaging sixty or eighty feet

above the ocean in the latitude of New-Jersey, they underwent no permanent elevation above the tide in the region further to the southwest, between the Chesapeake and the Roanoke.

"That the almost universal inclination of the planes of deposition in the red shale and sandstone formation is the result of the oblique or slanting mode in which the sediment has been laid down by a rapid and *steady* current, and is not due to any upheaving action, admits, I conceive, of very little doubt. If it were a consequence of the latter cause, the vast width of the region in New-Jersey over which this northwest dip prevails would imply a thickness for the deposit so enormous as to be beyond all precedent among stratified formations. But we have conclusive evidence of the comparative shallowness of this group of beds, in the fact that in several localities, even in the interior of the belt, it has been washed off in patches by denudation, so as to expose the subjacent Appalachian limestone, which appears in these places to have been the original floor of the basin. The denudation along the southeastern border of the tract has, in like manner, in many neighborhoods, cut away the coarse sandstone and conglomerate beds (the first deposited, and undermost, by order of dip), making the now undermost layers to consist of the red shales. This could obviously not occur if the materials had been precipitated in a nearly level position, as in that case they would have spread themselves along the bottom of the trough too far to the northwest to be removed by local denudation along its southeastern margin.

"The very general dip of the strata towards the northwest and north seems plainly to imply the side from which the sedimentary matter chiefly entered this valley. That the lateral influx was principally from the belt of country immediately bordering the basin upon the *southeast*, there can be little doubt; and we have only to observe the nature of the rocks skirting that side of the belt in a broad tract, the whole length from the Susquehannah to North-Carolina, to find at once the red soil of which these strata consist. Throughout this distance, talcose, chloritic and hornblendic rocks compose nearly the entire zone of country lying immediately southeast of the red shale; and the red soil which they produce is so identical in aspect and composition with the shales, and is at the same time so *copiously* furnished by their disintegration, as to point plainly to these primary strata as the source of most of the matter of this middle secondary trough. If we conceive the northwestern side of the valley next the base of the hills to have been, as it probably was, the deepest portion, and the red ferruginous materials to have entered this large river from the neighboring talcose rocks by currents setting obliquely *across* and *down* the channel, we may at once explain, not only the origin of these beds, but their inclined position, and their predominant northwestern and northern dip.

"In attempting thus to account for the prevailing dip of the red shale and sandstone strata, I am aware of the local exception to be found in the southeastern inclination of the beds between Middlebrook and Pepack, and its seeming incompatibility with the above views. I would direct the reader's attention, however, to the peculiar position of the Mine mountain, jutting out into the estuary of the red shale, considerably to the southeast of the general line of coast. It is easy to conceive that its influence must have been to intercept the regular northward current, and to deflect it over a certain area into a species of *eddy*, in which the

sedimentary matter would of course assume an unusual direction in its gently inclined surfaces of deposition. Proceeding east from the Round Valley mountain, we find the dip at the White Horse to be nearly northeast; then *east;* and near the mouth of the Lamington river, southeast; and beyond Somerville, nearly south, affording an almost convincing proof that such an eddy prevailed, and presenting ample evidence, if such were wanting, that the inclined posture of the strata is not the result of an elevatory action.

"Respecting the variegated calcareous conglomerates which overlie the red sandstone formation, but little difficulty exists in explaining both their source and the nature of the circumstances which accompanied their production. The fragmentary materials of which they consist, can be traced in every instance to the older rocks of the neighboring hills immediately bordering the middle secondary plain on the northwest; and we can discover a relation between the amount of the several kinds of pebbles, and that of particular sorts of easily abraded strata along the flanks of the valley. Thus, in every case where calcareous pebbles and a calcareous cement are abundant in the conglomerate, the older secondary limestone (Formation II.) may be seen at the base of the adjacent hills, and usually at an elevation that indicates it to have been sufficiently above the waves to undergo extensive destruction from a sudden and powerful rush of waters."*

I agree to the views of Prof. R. in the main, but would ascribe the deposition of the red sandstone to the operation of a cause more general; one that I believe will reconcile the facts perhaps better, and apply to other formations similar to this in other parts of the country.

It has been shown that the phenomena of the drift, and the deposits between that and those now under consideration, could be explained — in fact almost demonstrated that they must— by the operation of the laws of nature, have been caused by the action of branches of the polar and equatorial currents.

It can (and will in the proper place) be shown that the Blue ridge, Highland and Green mountain chain was elevated to the same general contour and relief as it bears at present, long before the deposition of the strata of the red-sandstone epoch.

It has been shown in the article on the drift deposits, that the polar and the equatorial currents must have existed as long as the ocean has occupied its bed; and flowing as it must, regulated by known dynamical laws, and mountain chains occupying positions the same as they now do, and as we know that they must have done at the period of the deposition of the red sandstone strata, the current that we call the Gulf stream must have flowed along the eastern coast of the United States, where the red-sandstone formation now is, and to the eastward of it.

It has also been shown that the general tendency of that current, as it progresses farther to the north, is to bend off slightly to the eastward, in consequence of the greater velocity of rotation at the equator than it has where distant from it, and nearer the axis of rotation. The reverse holds true with regard to the polar current.

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* Prof. H. D. Rodgers' Geological Report of New-Jersey, 1840, pp. 166, 171.

It has also been mentioned that a branch of the polar current has flowed through the Champlain and Hudson valley from a very early period of geological chronology, and will be demonstrated in the proper place.

To the influence of the meeting of these two currents checking their velocities, we would ascribe the greater breadth of the depositions of red sandstone in New-Jersey and Pennsylvania than farther south; and also the dip of the strata and laminæ of deposition to the west and northwest, as a consequence of the tendency of the polar current to flow beneath the other, and to press towards the west as it progressed farther south: thus producing, by a resolution of forces, the transport from the eastward to the westward.

The application of the same principle will, perhaps, explain the easterly dip almost universally observed in the strata of the red sandstone of the New-Haven and Connecticut valley. The strata of older rocks being directed north-northeast, and the ridges having the same direction, would deflect a part of the northern flow of the equatorial current along our coast into the Connecticut valley at New-Haven, and west of it over the country between there and the Green mountain and Highland range; and while its natural tendency would be more towards the east, to pass over the ridges and through the transverse valleys in that direction, the moderate amount of the flow of the *polar current* from the north through that valley (owing to the relative elevation of the head of that valley) would not very materially vary the direction of the former as the current causing transportation; and the polar current would also, on account of its *westward* tendency, flow mostly on the western side of that valley.

The red-sandstone formation east of the Rocky mountains, and along their base to the Polar sea, is presumed to be due to the action of the same general cause acting along those mountains as a coast, as that which produces a similar formation in the Atlantic States and Nova-Scotia; namely, the action of branches of the equatorial and polar currents. To the underflow of the polar current through the Hudson valley, cutting off the farther transport of materials by the gulf stream in that direction, I attribute the absence of all traces of the red sandstone formation on the left or east bank of the Hudson.

Geological Age of the Red Sandstone.

1. Professors W. B. Rodgers and H. D. Rodgers have shown that this formation is more recent than the coal formation.*

2. The examinations on Long and Staten islands have shown that it is more ancient than the formations of Long island that are equivalent in age to the potter's clay formation of New-Jersey, which underlie the marl deposits, and which are considered as probably equivalent to the greensand of Europe.

3. Prof. Hitchcock has shown, "that the fossil fishes found in this formation in Deerfield, West-Springfield and Sunderland in Massachusetts; at Glastenbury, Middletown, Berlin,

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* Geological Report of Virginia, 1839, pp. 71, 72, as quoted by Prof. Hitchcock in the Final Geological Report of Massachusetts, 1840, p. 438. I have no copy of that report for 1839.

Durham and Southbury in Connecticut; and of Morris county, New-Jersey, belong to that division of Agassiz's classification, which he calls *Heterocerci;* that is, having tails with unequal lobes, and called *unsymmetrical* or *heterocercal.* In these the scales, and probably the vertebræ, extended to the extremity of the upper lobe. Such fish have been found rarely, if at all, in any formation above the new red sandstone. Hence, then, any rock containing them in Massachusetts, Connecticut and New-Jersey," (and he might have added New-York,) "must be as old as the new red sandstone."*

The position occupied by the red sandstone under consideration, may be considered then to be that of the new red sandstone, as it is above the coal, below the greensand, and below those beds called the potter's clay; which, if we have any beds equivalent to the lias and oolite, would occupy their position. Many collateral evidences are adduced by Prof. Hitchcock which are not *decisive*, but afford *presumptive* evidence tending to the same conclusion. The principal of these are, first, lithological characters; secondly, the bones of vertebrata that were not fishes, and found in the sandstone; and thirdly, the tracks of birds and animals found on the sandstone in quarrying.† ‡

Prof. Hitchcock was considered years ago as having *almost* demonstrated the equivalency of the red sandstone of the Connecticut valley, to the *new red sandstone.* There can be scarcely a doubt, that the red sandstone east of the Blue ridge and Highlands; that of the Connecticut, and of the Housatonic valleys; and doubtless those of Lake Superior, the Rocky mountains, and Nova-Scotia, are identical in age, as they are in their general characters and in their associated rocks and minerals, and in their fossils so far as we know. The more recent observations of Prof. H., those of Professors Rodgers in Virginia, Pennsylvania and New-Jersey, and my own in New-York, afford additional evidence tending to the same conclusion.

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* Prof. Hitchcock's Geological Report of Massachusetts, 1840, p. 438.

† I have seen no tracks on the red sandstone of Rockland and Richmond counties, but they may very possibly be found there. My researches were necessarily very limited, in examining this, and in fact all the regions explored in New-York. The law required the surveys to be made in a fixed time; and to satisfy public opinion, equal times were devoted to exploring equal areas. The consequence is, that scarcely more than a reconnoisance has been made of *any* part; and the most interesting fields for geological research had scarcely begun to open their treasures of facts, before they were left for new fields of labor.

‡ I have numerous specimens of the fishes from this formation in Connecticut, where I have dug out hundreds of them. Those at Durham are in a bituminous calcareous slate, and the animal matter is changed to bituminous coal. The following section shows the position of the fishes:

1. Drift and gravel beds.
2. Red sandstone.
3. Red and grey crumbling sandstone (very fissile).
4. Calcareous slate containing ichthyolites.
5. Sandstone and slate (fissile).
6. Shale.

CHAPTER V.

COAL SYSTEM.

The coal formation can scarcely be said to be found in the First Geological District, or even within the State of New-York. The lowest beds only, the conglomerate and coarse grits underlying the coal beds, and forming the base of the coal formation, are found in small patches as outliers, on the summits of some of the high peaks of the Catskill mountains.

Although only the lowest rock of the coal formation is deposited within the boundary of the State of New-York, the most magnificent development of the coal formation known in the world is found on her borders; and the deposition of this, and all the rocks in the descending series down to the primary, seem due to the action of the same general cause as that to which we have ascribed the quaternary, and other systems of strata down to the coal formation, namely, to the action of the *equatorial* and *polar currents*. The directions of chains of primary rocks under the equator, and along the western, northern and eastern parts of the American continent, seem to have determined the direction of the equatorial current, and caused it to perform a circuit around from Mexico along the Rocky mountains, a part flowing into the Polar sea and Hudson's bay, and the remainder through the northern part of the United States and southern part of Canada, where it was again subdivided, one part flowing over and through the St. Lawrence valley, and the remainder over the Mohawk valley, and along the Blue ridge around to the Mississippi, where it would rejoin the same stream; the polar current through the St. Lawrence and Hudson valleys, and the valley of the Red river of the North and the Mississippi, tending to aid in the production of this circular flow. The meeting of these currents at particular points where they would necessarily be brought to conflict with each other's directions, and the forms of elevated tracts within this area, would tend to the production of eddies on a large scale, where floating bodies would be kept within certain areas for long periods, until, if of vegetable origin, they would become waterlogged, and sink.

To this cause, at the carboniferous period, we would ascribe the origin of the coal formations of North America. When we consider the vast accumulations of drift wood on the shores of the northern seas, as Greenland, Labrador, Spitzbergen, Iceland, &c., much of which is from the tropics, floated thither by the equatorial currents; and the drift weed almost always seen floating in the Atlantic between the tropics, which is carried westward and northward by the equatorial current at certain seasons, and accumulates in what may be termed

eddies on a large scale, and eventually sinks; we can scarcely be surprised at the vast accumulations of ancient vegetation over certain areas, where, from evidences that can be adduced, similar eddies must at that epoch have been formed, and similar effects have been produced.

This mode of explaining the origin of the coal formation in North America, will easily account for the tropical vegetation found even in the frigid zone; as one part of the equatorial current must have passed to the Polar sea between the Rocky mountains and Lake Superior, and may be expected to have floated the vegetation of the tropics.

I would not urge this matter, however, to the extent of contending that the climate has not greatly altered since the carboniferous epoch; for we have numerous evidences on that point, that may be considered as conclusive,

1. Mr. Lyell has satisfactorily shown that a different distribution of land and water, even without varying the absolute quantity, would materially influence the climates of the earth.

2. We have indubitable evidence that most of North America and Europe have emerged from the bed of the ocean since the carboniferous epoch.

3. Fossil plants, animals, testacea, zoophytes, etc., all indicate that they belonged to a warmer climate than the present; and those organic bodies to which reference is now made, lived and died where they are now found; and they are diffused over vast extents where the climates are now extremely varied, and are not all probably due to the genial influences of the warm equatorial current.

4. There are no known evidences of ice on the earth's surface until after the epoch of the carboniferous strata, and none with *certainty* ascertained until about the period of the drift deposits.*

The effects of large tracts of land emerging from the waters of the ocean in the temperate and frigid zones, such as we *know* have emerged since the carboniferous epoch, and even without the disappearance of any between the tropics beneath the ocean level, might be expected to be as great in changing the climates of the different regions of the earth as the changes we perceive, and independent of the secular refrigeration of the globe.

The plants of the carboniferous epoch are said by botanists to be vascular cryptogamic plants of tropical characters, and to indicate an insular, rather than a continental flora. Those of the more recent formations in the upper secondary and tertiary are dicotyledonous. The changes have been successive.

The coal formations of the United States, between the Blue ridge and Rocky mountains, have been already slightly alluded to on pages 2 and 3 of this volume. One of these, which we may be permitted to call the Ohio coal formation, as it nearly all lies within the basin drained by the Ohio, has its northeastern extremity near the Delaware river, in New-York,

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* Dr. Joseph Barratt, of Middletown (Conn.), an ardent naturalist, and favorably known as a botanist, showed me examples of what he considered to be the effect of the congelation of water in the red sandstone near Middletown, in 1837. The examples he shewed me bore some resemblance to the long shoots of crystals often seen on frozen mud; but they were not so striking as to force conviction on my mind. Dr. B. is, I believe, the first observer of such facts. I hope he and others will investigate the subject farther, and ascertain if these and similar appearances are due to frost.

and extends along the southern boundary of New-York, and thence south and southwest into Alabama, a distance of sixteen hundred miles, with an average breadth of at least fifty miles, and perhaps one hundred miles.*

Within this great coal formation, the largest in the known world of which the boundaries have been explored, it is supposed that there are from fifty thousand to seventy-five thousand square miles of workable and easily accessible coal, in beds three feet thick and over, giving an average thickness of workable coal twenty feet thick. Taking the lowest of these estimates as the basis of calculation, it will yield 32,234$\frac{4}{100}$ cubic yards per acre; or 20,630,016 yards per square mile; or 1,031,500,800,000 cubic yards for fifty thousand square miles; and as a cubic yard weighs about a ton or rather more, it may be stated as so many tons. This quantity would give more than three tons annually to each individual of the present population of the United States for twenty thousand years, a quantity sufficient not only for domestic use, but for all purposes of machinery and working the metals, etc. The above quantity, also, if put in mass, would form a square pyramidal mountain with a base ten miles square, and thirty thousand feet high; or a range of mountains two miles through the base, twenty-five hundred feet high, and nearly two hundred miles long.†

When it is remembered that this is only *one* of several great coal formations in North America, one at least of which is supposed to be of equal extent with this, while there are several small ones, (but which compare with the largest of those of Europe,) we see what a wonderfully bounteous provision has been made by our Creator for the comfort, happiness and prosperity of his creatures in this, as *one* of the elements of social and domestic enjoyment, of individual and national wealth.‡

Extensive derangements of the strata of the coal system have taken place since their deposition; but while in Pennsylvania, Maryland, Virginia, &c., mountain chains have been elevated, and various wrinklings of these and the subjacent strata have caused long mountain chains and valleys; in New-York, only the subjacent strata have been affected on the prolongation of those anticlinal and synclinal axes, and where they were not covered by the carboniferous system. These derangements of the strata will be mentioned when we treat of the strata that have been affected by them in New-York, and they will be referred to their relative epochs, as near as can be ascertained from the facts thus far obtained.

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* Small portions of this coal formation are drained by some of the branches of the Delaware and Susquehannah in Pennsylvania, the Cuyahoga in Ohio, and the Alabama river in Alabama.

† The coal of this formation now finds a market in the State of New-York, through the Ohio canal and Lake Erie to Buffalo, and along the Erie canal; from Pennsylvania, through the Genesee Valley canal, Chemung canal, the Chenango canal, the Delaware and Hudson canal, and the Morris canal; to the Middle States, through the various canals in Pennsylvania, the Chesapeake and Ohio canal; and to the Western and Southwestern States, through the Allegany, Monongahela, Ohio, Kenawha, Sandy, Leckinep, Kentucky, Cumberland and Tennessee rivers. Vast quantities are already used for manufacturing operations, for steamboats, and for fuel, but the use has only commenced.

‡ Associated with these coal strata are others of limestone, ironstone, fire-clay and fire-stone, with various qualities of sandstone, clay, etc., all of which are calculated to be made elements of inexhaustible sources of industry, production and wealth, in the manufacture of iron, glass, pottery, etc. The beds of iron ore associated with the lower coal beds will probably yield on an average 10,000 tons of iron per acre, or 6,400,000 per mile, or 320,000,000,000 of tons from this formation.

CHAPTER VI.

NEW-YORK SYSTEM.

This embraces all the rocks from the Coal formation to the Taghkanic system, including the Devonian system of Mr. Phillips, the Silurian system of Mr. Murchison, and most of the Cambrian system of Mr. Sedgwick. The name of New-York System is given as a geographical one; not that the rocks are confined to New-York, for they really occupy a very large proportion of North America, and probably more than one-half the land of the temperate zones of the earth; but because they are in New-York better developed, and are so situated that their superposition and fossil and mineral characters can be more easily studied than in any other part of the earth where these rocks have been examined. The dip is generally very slight, and the valleys of streams and the escarpments of the mountains offer every facility for a rigid determination of the order of superposition, the thickness, fossil and mineral contents.

In the *Hudson valley* from Lake Champlain to Kingston, and thence through the Walkill and Mamakating valleys (which are the extension of the original valley of the Hudson), the lower rocks of the New-York system are upturned on their edges, overturned, folded and wrinkled in various ways. If an individual were to confine his attention to these deranged masses to unravel the order of superposition, he would, as he progressed, find it like "confusion worse confounded." It was not until I had become well acquainted with the general characters of the horizontal and the upturned rocks, and with the axes of disturbance, that these upturned rocks, which are frequently altered by intruded matter in the form of basanite, quartz, and sometimes trap, that they were with certainty recognized as of the same geological age. The rarity of the characteristic fossils in these lower rocks, and even of *any* fossils, in strata which farther west are replete with them, added to the difficulties in identifying them.

The strata of the New-York system cover a vast area in the United States between the Blue ridge and Rocky mountains, and between the Gulf of Mexico and the Primary ridge north of the Great lakes. They all seem due to the action of the same cause that has produced the transportation of the Drift, Quarternary, Long-island, Red-sandstone and Coal formations. The great extent, thickness and uniformity of fossil and mineral contents of this system, point to the action of the same cause, continued through long periods of time, some-

times depositing sandstone, sometimes slate, limestone, etc., varying at intervals; and we can perceive no origin from which such a vast amount of mineral matter can have been abraded and washed away, as we see forming this immense accumulation of detritus, unless it has been brought by the equatorial and polar currents in their ceaseless flow through all time since the ocean has occupied the surface of the earth.

Some of the strata of this system are more fully developed in the west, and gradually thin out and finally disappear, or are represented by a thin layer on the southern flank of the Mohawk valley, or on the western flank of the Hudson valley; but generally the reverse is true, and the maximum development is found in the angle between these two valleys; and these depositions seem to have been formed in a kind of eddy, produced by the meeting of the flow of warm water of the Gulf stream through the Mohawk valley, with the cold Polar current through the Champlain and Hudson valley.*

The cold northern current flowing through the Champlain and Hudson valley, would offer a satisfactory explanation of the rarity of the remains of organic existence in these rocks in that valley; while they abound in depositions of the same mineralogical characters, which are, in fact, the continuation of the same strata, on the flanks of the Mohawk valley, and throughout the southern part of New-York west of the Schoharie kill. In the latter case, they were exposed to the genial influences of the equatorial current; in the former, to the chilling cold of the polar stream.

The strata of the New-York system will be considered under the following general divisions, viz:

New-York System.
1. Catskill division.
2. Erie division.
3. Helderberg division.
4. Ontario division.
5. Champlain division.

I. CATSKILL DIVISION.

Upper members of the Catskill mountain series of the Geological Reports for 1840 *and* 1841. *Montrose sandstone, and Oneonta sandstone of Geological Reports of New-York. Old red sandstone, probably, of Europe. Nos.* 9, 10, 11 *and* 12, *of the Pennsylvania Geological Reports. Old red sandstone, No.* 9 *Mr. Conrad's arrangement.*†

The Catskill division of rocks consists of coarse and fine grits, with various shades of red, brown, grey, greenish, and mottled red and green, which lie thick bedded with the oblique laminæ of deposition strongly marked (vide Plate 6, figs. 1, 3 and 4);‡ conglomerates of

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* The reasons for and evidences of those currents have been traced in the article on the drift deposits, in the latter part of the second chapter.

† Geological Report of New-York, 1839, p. 62.

‡ Vide also Wood-cut No. 8.

various degrees of coarseness, greyish, greenish and red; slaty fissile sandstones, with slates and shales of various colors, as red, green, and mottled with these colors, grey and black. Testaceous fossils are extremely rare. Terrene and marine plants are more common.

The following engravings, figures 7, 9, 10, 11, 12, 13, illustrate some of the fossils of this division of rocks:

Fig. 6.

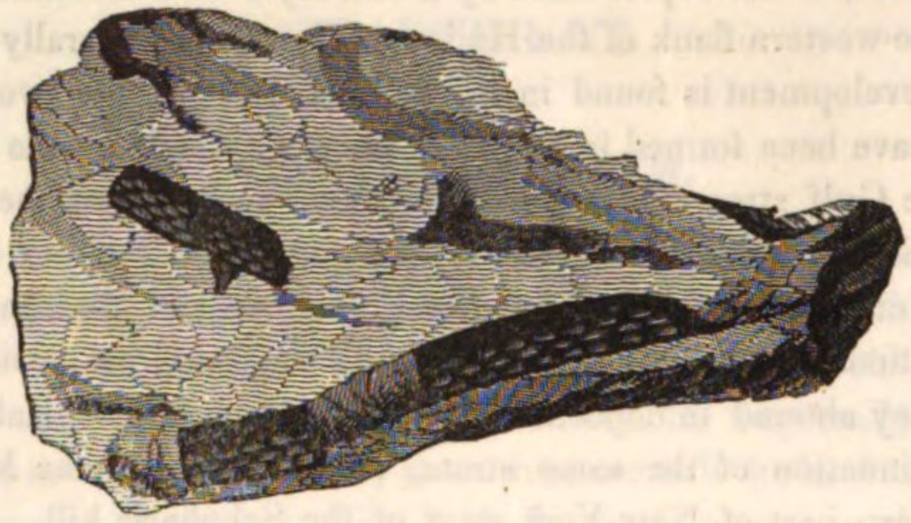
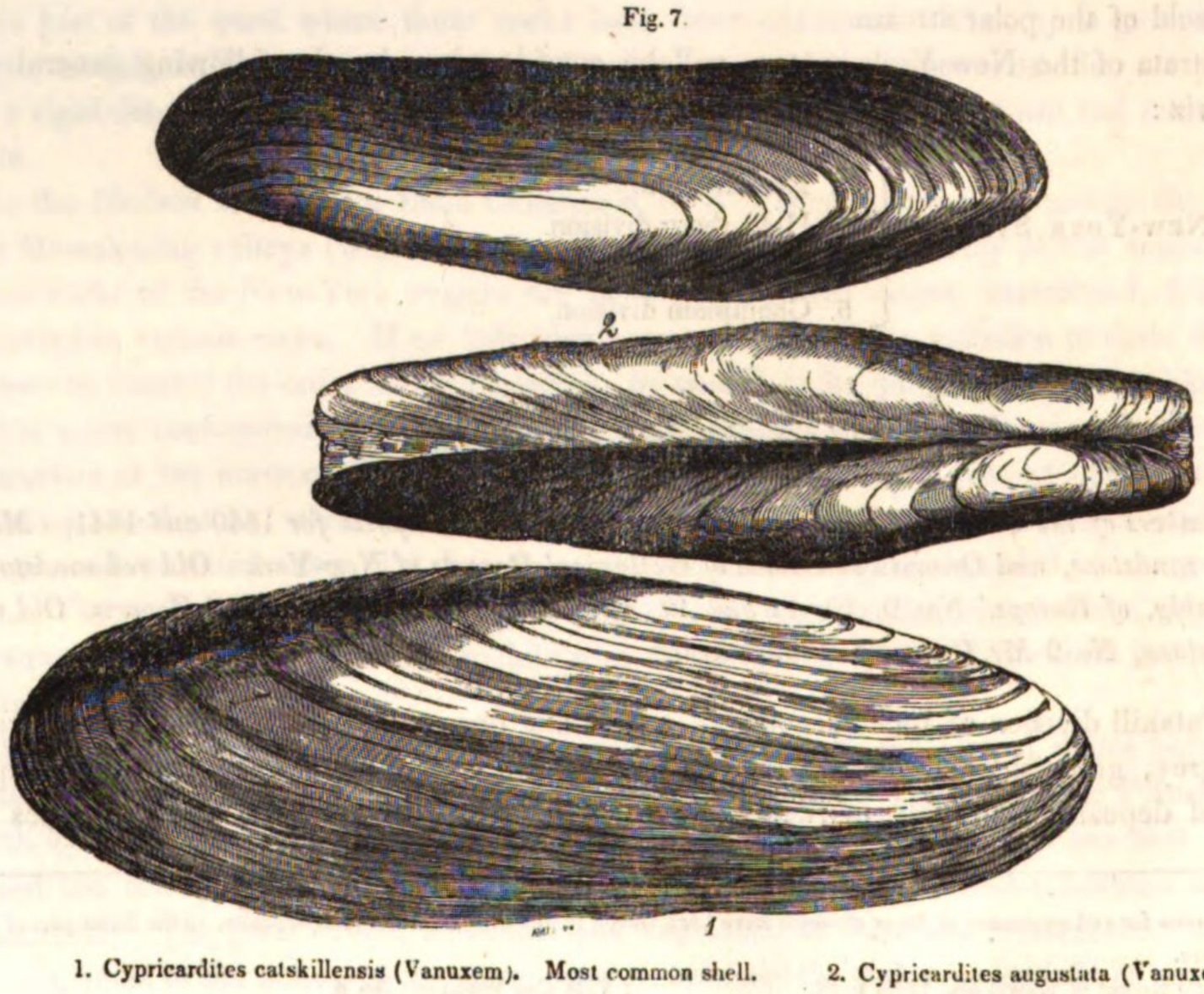
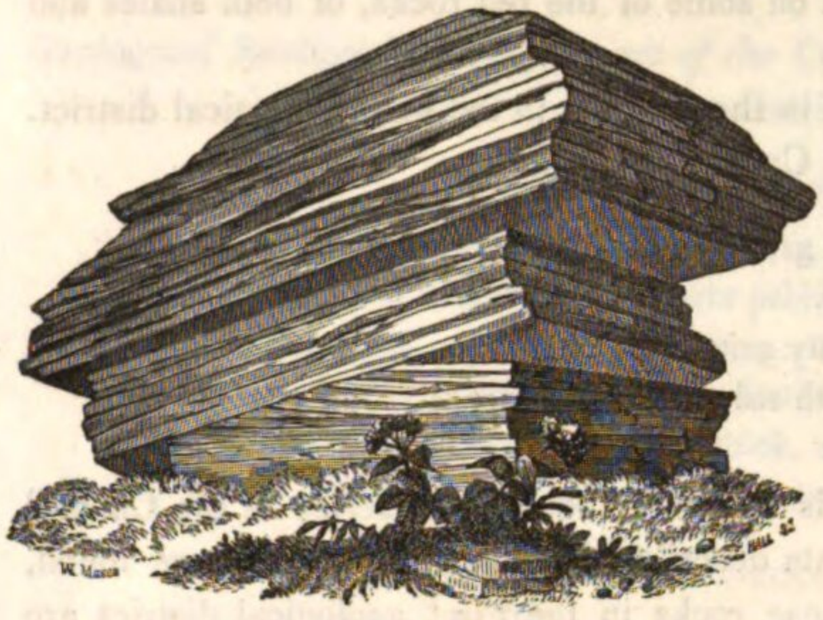


Fig. 7.



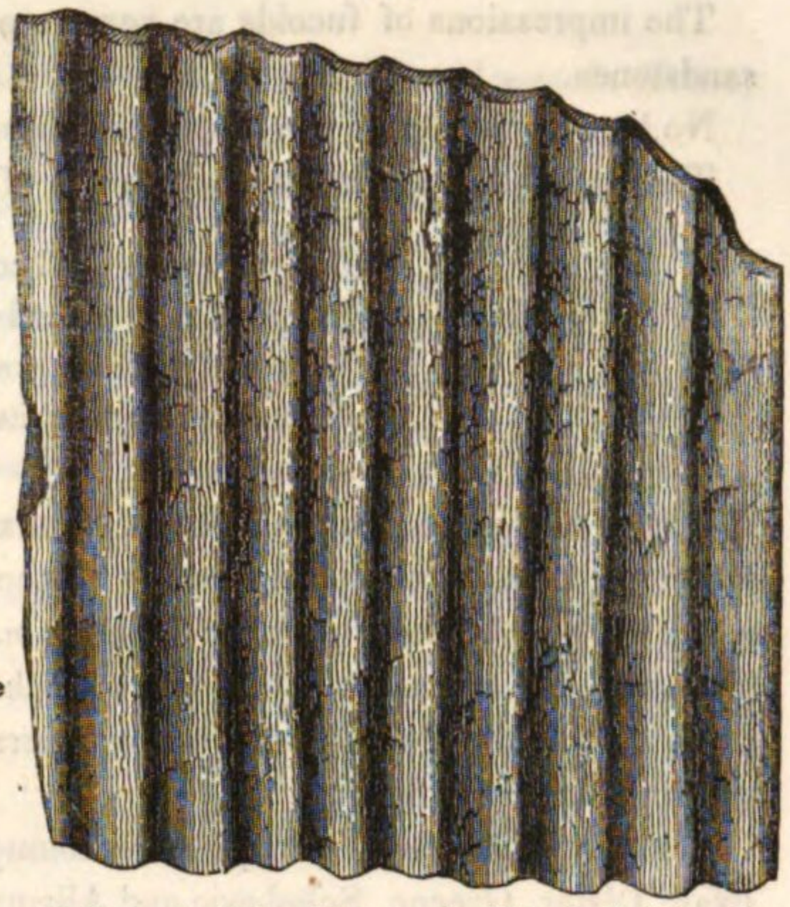
1. Cypricardites catskillensis (Vanuxem). Most common shell. 2. Cypricardites augustata (Vanuxem).

Fig. 8.



This illustrates the laminæ of deposition so strongly marked in the sandstones of the Catskill division. (Vide also Pl. 6, figs. 3 and 4.)

Fig. 9.



Sigillaria simplicitas (Vanuxem). This fossil differs from that of the Coal formation, in having no markings on the elevated parts.

Fig. 10.



Fig. 11.



Fig. 12.



Fig. 13.



Fig. 13 is the most common impression of a plant in the Catskill division.

The impressions of fucoids are very common on some of the red rocks, of both shales and sandstones.

No bones or scales of fish have been observed in these rocks, in the First geological district.

The general arrangement of the parts of the Catskill division is,

1. Conglomerates, and coarse grits.
2. Red shales, slates and grits.
3. Grey and greenish grey slaty grits.
4. Chocolate-colored grits, with red shales and slates.

The Montrose sandstone of Prof. Vanuxem is below the top of this series in the Catskill mountains; and beneath this, nearly all the strata described by him in his reports are found, characterized by their peculiar fossils; but these rocks in the First geological district are generally of a coarser texture, down to the Helderberg limestone series, than in the Third district; and the fossils are as rare comparatively in this, as they are abundant and beautifully preserved in the other.

The Catskill division occupies the county of Delaware, and portions of the counties of Sullivan, Ulster, Greene, Schoharie and Albany. Seams and layers of pure anthracite have been observed in some places, and fossil plants have been found, not only in the shales associated with the anthracite, but also abundantly in the grits and slaty sandstones of the middle and upper parts of the series. These strata are all below the coal-bearing rocks of Pennsylvania, and it is not considered probable that coal will be found in useful quantity in them.

By referring to the Geological map of the State, it will be seen that the Catskill division occupies a small area in the Third and Fourth geological districts, along the southern boundary of the State, but the main body of it forms the elevated land called the Catskill mountains.

Two main systems of joints traverse these rocks, and all the subjacent ones down to and into the primary, and they conform in direction to the main axes of elevation and fracture, namely, north-northeast to south-southwest, and east-southeast to west-northwest. These joints are nearly vertical, and in slaty rocks are very smooth, as smooth as if cut through with a saw. They afford great facilities for quarrying, and save much labor by having their faces smooth-dressed by nature.

The following detailed section gives the rocks as they can be seen, from the top of the South mountain near the Mountain House on the Catskills, down to the Helderberg division at the Katerskill creek at the Stone bridge between Catskill village and the Mountain House. They are grouped as they occur in terraces, which are numbered from the church in the valley, up to the toll-gate at the immediate base of the mountain, and thence up the mountain to the shanty in the ravine.

Geological Section from the summit of the Catskill mountain, south of the Mountain House, to Catskill creek.

LOWER GRITS OF THE COAL FORMATION.

		FEET.
1.	Grey slaty grit containing some pebbles,	40
2.	Conglomerate of white and red quartz pebbles, intermixed with those of grey slaty grit,	
3.	Brown slaty grit,	30
4.	Grey slaty grit, very thin (one to two feet),	
5.	Conglomerate about twenty-five feet thick, exposed,	
— O ——	No rock seen, covered with debris,	40

CATSKILL DIVISION.

6.	Grey grit with some pebbles,	8 feet	37
7.	Bluish shale, (local merely,)	1 foot	
8.	Grey grit,	8 feet	
9.	Grey grit, with some pebbles,	20 feet	
10.	Red shale, down to Table rock at Mountain House,		50

Table Rock on which the Mountain House stands.

11. Grey slaty grit.
12. Red shale.
13. Brown grit.
14. Red shale.
15. Grey grit.
16. Red shale wtth green spots.
17. Brown grit.
18. Greenish grey grit.
19. Brownish grit.
20. Red shale (thick stratum).
21. Brownish red grit.
22. Brownish red shale.
23. O ———— No rock seen; covered with soil.
24. Brownish red grits and shales.
25. Reddish gritty shales, (green spots.)
26. Red shale.
27. Greenish grey grit.
28. Reddish brown shale.
29. Greenish grey grit.
30. Reddish grit.
31. Red shale.
32. Brown grit.
33. Red shale.
34. Grey grit.
35. Red slate, spotted with green.
36. Red shale.
37. Brownish red grit, (contains fucoids.)
38. Red shale with green spots.
39. Grey and red slaty grits.
40. Brownish shale.
41. Red shale.
42. Brownish red slate.
43. Greenish shale.
44. Red shale, with green spots.
45. Brownish red shale.
46. Greenish grey grits.
47. Red shaly grit.
48. Greenish grey grit.
49. Red shale.
50. Green shale.
51. Reddish brown grit.
52. Brownish red shale.
53. Red shale.
54. Greenish brown shale.
55. Grey grit.
56. Reddish shaly grit.
57. Brownish red slaty grit.

58. Green shale.
59. Red shale.
60. Brown grit. (Band one foot thick.)
61. Red shales with green bands.
62. Brownish grey grits.
63. Brownish red shaly grits.
64. Reddish grits.
65. Greenish grey slaty grits.
66. Brown and greenish grits.
67. Grey laminated grits.
68. Red crumbling grit.
69. Reddish slaty grit.
70. Red shale.
71. Green shale at the shanty in the ravine.

Terrace No. 18.

70. Red shale. } These two strata are the same as the two preceding, and are crossed again, in rising, and descend again from the shanty in the ravine.
71. Green slate. }
72. Red shale.
73. Reddish grey slaty grit.
74. Red shale.

Terrace No. 17.

75. Grey grit.
76. O ———— No rocks seen, soil, etc. cover them.
77. Red shale.
78. Greenish grey slate.
79. O ———— No rocks seen, soil, etc. cover them.
80. Red shale with green spots.

Terrace No. 16.

81. Grey grit.
82. Red shale with green spots.
83. O ———— No rock visible.

Terrace No. 15.

84. Greenish grey slaty grits.
85. Greenish grey shale.
86. Grey slaty grits.

Terrace No. 14.

87. Grey slaty grit.
88. Red and brownish red shales.
89. Grey grit.
90. Red and green shales alternating.
91. Brown slaty grits.

Terrace No. 13.

92. Red shale with green spots.
93. Greenish grey grit.
94. Red crumbling grits.

Terrace No. 12.

95. Red and green shales.
96. Grey slaty grits and shales.
97. Brownish shale.
98. Red shale with green spots.
99. Grey shale.
100. Red shale. To the toll-gate.

Terrace No. 11.

101. Green shaly grits.
102. Greenish and brownish shales.

Terrace No. 10.

103. Grey grit, laminæ of deposition distinct.

Terrace No. 9.

104. Grey grit, laminæ of deposition distinct.

Terrace No. 8.

105. Grey shale.
106. Greyish green shale.
107. Red and green spotted shale.
108. Grey grit laminated.
109. Brownish red shale.
110. Grey grit.
111. Brown shale.
112. Red shale.
113. Brown sandstone.

Terrace No. 7.

114. Red shale, green spots.
115. Grey slaty grit, to bottom of valley.

Terrace No. 6.

116. Brown slaty grit.
117. Grey slaty grit.
118. Blue slaty grit.

Terrace No. 5.

119. Red slaty grits with shales interlami-
120. Bluish grey slaty grit. [nated.

Terrace No. 4.

121. Grey slaty grit.
122. Brown crumbling grit.

Terrace No. 3.

123. Grey crumbling shale.
124. Red and green spotted shale.
125. Brown crumbling shale.

ERIE DIVISION.

Terrace No. 2.

126. Grey slaty grit.

Terrace No. 1.

127. Grey slaty grit, to Kiskatamine creek, at the church in the valley.

Terrace No. 1'.

128. Grey slaty grit.
129. Limestone, brecciated and conglomerate, two feet.
130. Grey slaty grit.

Terrace No. 2'.

131. Grey slaty grit; laminæ of deposition distinct.

Terrace No. 3'.

132. Dark shales and shaly grits and flags, of several hundred feet in thickness, embracing from the Ithaca group to the Marcellus shales of Prof. Vanuxem.
133. Marcellus shales, at the stone bridge, Caterskill creek.

HELDERBERG DIVISION.

134. Helderberg limestone, at the stone bridge, Caterskill creek.

The strata embraced in 132 have not been traced out in detail as those above have been.

Numerous fine sections were observed in the various ravines in the Catskill mountains, some localities of which will presently be mentioned; but the preceding and subjoined sections shew the general arrangement of the strata of the Catskill division.

Subjoined is a local section of a small portion of the Catskill division, at Post's mills, in Durham, Greene county.

	FEET.	INCHES.
1. Grey grit at the top of the ravine, surface rock,		
2. Red shale,	4	0
3. Greenish grit,	20	0
4. Red grit and red shale,	15	0
5. Hard band of red grit,	2	0
6. Red shale,	2	0
7. Hard band of red grit,	2	0
8. Slaty red grit,	2	0
9. Red gritty shale,	4	0
10. Greenish gritty shale,	3	0
11. Reddish slaty grit,	7	0
12. Green band of shale,	1	0
13. Red gritty shale,	5	0
14. Blue limestone, compact,	0	6
15. Red shale, and thin band of slaty grit,	8	0
16. Slaty sandstone, some spotted with green,	6	0
17. Green shale, and bands of red grit, unknown thickness.		
	81	6

The stream at these mills has cut a deep ravine or gorge, with sides that are perpendicular in some places, and a fine view of these rocks is thus exposed. Fucoids are found in these rocks, as also in a large portion of those in the section of the Catskill mountain, from No. 11 to 131. Shells and terrene plants are found in the strata embraced in No. 132. The strata from No. 70 to 122 inclusive, are grouped in terraces. The strata above the shanty in the ravine half way up the mountain on the road from Catskill to the Mountain House, are not grouped on the section into terraces, on account of the difficulty of defining their limits in ascending along the road, which is, of course, made in the most favorable location; but at a distance from the mountain, where the eye can observe a greater area, the mountain is seen to be divided into regular terraces to its very summit. The series is capped by a quartzose conglomerate, which may be seen well developed on the South mountain, south of the Mountain House.

The road from Catskill to the Pine orchard, at which the Mountain House is located, exposes a large proportion of the rocks of the First geological district, and of the State, in the short distance of twelve miles, and crosses the main anticlinal axis of the Hudson valley. The Hudson river slate series is seen in part at Catskill, dipping at a high angle to the east-southeast, overlaid unconformably by the clay, sand, and gravel deposits of the Hudson valley. The Helderberg limestone series, with its peculiar fossils, is seen along the anticlinal axis, very much broken up, and dipping in various directions; but near the Caterskill, the limestone dips rapidly to the west, and is overlaid by the black Marcellus shales at the stone bridge on the road to the Mountain House. The Caterskill valley is here filled with the clay beds of the Hudson valley, so as to conceal the rocks; but half a mile west, the rocks of the Erie division are seen in the high hill dipping at about the same angle, but gradually diminish in the angle of dip as we approach the mountain. This part of the series can be examined satisfactorily, only, by following up the bed of as tream near which the turnpike passes. These strata are of probably one thousand feet in thickness, and are embraced on the section in No. 132.

From Caterskill creek, the strata emerge in a succession of terraces, with a steep, bold escarpment on the east; but they slope away gradually to the west, until at the base of the mountain, the rocks seem to be horizontal. Each terrace is capped by a hard grit, or other rock that has been able to resist the action of the weather and water. The mountain, when viewed from a distance, has the appearance of rising by successive steps. Each terrace from the bottom upward is nearly level, but they are narrow near the top of the mountain.

Although the strata on the mountain seem to the eye to be horizontal when viewed near, they are evidently not so when seen at a distance where the eye can at once grasp a great extent in view, and trace the particular strata and terraces along the front of the mountain and up the various valleys. They are seen to dip at a slight angle to the southwest.

The strata on the section of the Catskill mountain from 11 to 132, are generally from ten to fifty feet thick each; some few are thinner, but the aggregate cannot be much less than four thousand feet for those strata, unless there should prove to be faults, that may have caused

the same strata to be repeated in the section. Care, however, was taken to guard against this cause of possible error.

The stratum of brecciated and conglomerate limestone in the section of the Catskill mountain, is found over a great area in the Catskill mountain region, although rarely more than one foot thick. This stratum often contains small quantities of carbonate and sulphuret of copper, (black) carbonate of iron, and sulphuret of zinc. It is so extensive, although thin, that it is a good reference stratum, to determine in what part of the series any particular stratum is situated that one may be examining.

At Gilboa, the red shales and grits of the Catskill mountain rocks are seen in the creek valley, from the water level to two hundred feet above; and thence they are found all along the valley to Hunter, and thence to the Mountain House. Fucoids abound in some of these strata.

Fine sections are also exposed in all the valleys of the branches of the Schoharie kill above Gilboa, as,

1. On the Manor kill, from Gilboa by Strikersville, in Broome, Schoharie county, to Durham and Cairo in Greene county, on the Catskill creek.
2. About Prattsville, and on the Batavia kill and all its branches, in Windham, Greene county.
3. On the East kill and its branches, in Lexington and Hunter, in Greene county.
4. On the Schoharie kill, in Lexington and Hunter, Greene county.
5. On the West kill and its branches, in the same towns.
6. On Catskill creek and Foxes creek, near Potter's Hollow and Preston Hollow villages, in Rensselaerville township, in Albany county.
7. On the roads crossing the mountain, from Cairo to Windham, and from Durham to Windham, and from Durham to Cairo in Greene county.
8. On the road from Catskill to the Mountain House at the Pine orchard, between Kiskatamine creek and the top of the mountain. A section on this road has been given.
9. On the road from Catskill to Hunter, through the Kaatersville clove.
10. On the road from Woodstock in Ulster, to Hunter in Greene county.
11. On the road from Saugerties, through the Plattekill clove, to Hunter in Greene county.
12. On the Esopus creek and all its branches above the falls in the town of Olive, to their sources in Ulster county.
13. On the branches of the Rondout kill in Shandaken township, and in the northwest part of Wawarsing, Ulster county.
14. On all the streams and roads of Sullivan county, except the town of Mamakating, and the east parts of those of Forestburgh and Fallsburgh.
15. At the falls of the Shingle kill in Deerpark township, in the northwest part of Orange county.
16. On all the roads and streams in Delaware county, except in parts of Harpersfield and Davenport.

17. Many very fine sections may be examined in Delaware county. It is perhaps useless to mention localities where they may be seen on almost every road, and in every valley; but some of the finest were observed on the Willewemock river, which is the main tributary of the east branch of the Delaware. It is called, on Burr's map of Delaware county, the Beaver kill; but the Beaver kill is the main northeastern branch, that has its source in Shandaken, Ulster county, and flows mostly in Sullivan county, within a mile or two of the line of Delaware county, and unites with the Willewemock river about a mile south of the line of Delaware county. The mountains come so close upon this river, that for many miles above its mouth there is no road, and the explorer must leave his conveyance and go on foot or on horseback, frequently fording the river, or cross it on a floating log instead of a boat.*

18. At the falls of the Schoharie creek, near the meeting of the lines between the counties of Greene, Schoharie and Delaware, the red slate occurs at the bottom of the falls, and has been deeply excavated by the water; while the superincumbent thick-bedded strata of grit break off at the natural joints of the rock, and fall into the basin excavated below. The fall has thus receded.

19. A cliff overhanging the road on the bank of the Schoharie creek, near the line between Windham and Lexington, Greene county, offers a fine section of a few of the rocks. The red and reddish-brown colored slates and sandstones, and green slate, may here be observed. Some fucoids were obtained at this place. These strata are overlaid by thick-bedded grey grit.

20. Strikersville falls present a fine section.

21. The red and green variegated shales were seen in the bank at Catskill creek, one mile below Preston hollow.

22. The reddish sandstone and shale occur in the bed of the small creek in the village of Prink-street, in Durham. The grey grits also occur there, abounding in coarse, imperfectly characterized vegetable fossils. A thin bed of impure conglomerate limestone also occurs there. Ascending the mountain from Durham towards Woodstock, vegetable impressions are abundant in the grey grits which alternate with the red rocks. The impressions are usually not more than half an inch broad, and very imperfectly characterized, and are filled with coal when fresh broken. One stem was observed about six inches in diameter and one and a half foot long, imbedded in a loose mass of the grey grit (vide Pl. 25, fig. 9). The general form and the joint were alone distinct; none of the cortical markings were distinguishable.

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* The wild mountain scenery, the country in a state of nature with its magnificent forests, the bracing mountain air, the pure limpid cold waters abounding in the finest trout, would, I should think, offer inducements to many who have no taste for geological investigations, to visit such scenes. I have often caught as many fine trout in a few minutes as my party could consume, and had them cooking as soon as they had ceased to flap, when encamped in the wild mountain regions of Delaware, Sullivan, Ulster and Greene counties.

Dr. Hubbard of Prink-street has in his collection a very large specimen of a vegetable fossil found in the grey grit rock, a foot in diameter. Some of these plants have a long and delicate leaf, like some of the grasses; and these and others bear a strong resemblance to some of the fossil plants in the anthracite coal, shales and grits in Pennsylvania.

23. The grey grits and the interstratified red grits and shales were observed on the hill between Preston-hollow and Oakhill, one to two miles from the latter place. They appear to be the same rocks as those that plunge below the creek between Preston-hollow and Young's, at the Depot on the railroad, and at Prink-street. These locations would seem to indicate a slight westwardly dip.

24. The grey grit was seen one or two miles from Prink-street in Durham, on the road to Catskill, covered with a double set of scratches, and underlaid by the red grits and shales. (This locality has been mentioned in the table of localities of scratches.)

25. At Post's mills, in Durham, Greene county, the stream has cut a deep gorge in the red grits and shales, similar to those under the grey grits mentioned in the paragraph above. The same grey grits here overlie the red grits and shales, as that on which the scratches were mentioned. A section of these grits, etc. has been given. Vegetable impressions abound in the grey grit at this place. Vegetable impressions were seen abundantly in the grey grits in a quarry about one mile west of Oakhill.

26. The red grits and shales were observed in the bed of a creek between Hickok's sulphur spring in Greenville, and Freehold, at the leather factory.

27. The red grits and shales, and the thin bed of blue slate, are well exposed in the right bank of the Catskill creek, three quarters of a mile above Pleasant-valley, in the southwest part of Rensselaerville township, Albany county.

28. The reddish or chocolate-colored grits were seen in the banks of Fox creek, between Preston-hollow and Weeden's sulphur spring in the same township.

29. The red and variegated grits, red with green spots in the grit, and with the green band of shale, were seen at the mill-dam near Potter's-hollow, three quarters of a mile west of Pleasant-valley.

30. The red grits were seen west of Potter's-hollow, in ascending the mountain. These were succeeded by the grey grits, and these last by several hundred feet of the chocolate-colored grit, and this was capped by one hundred or two hundred feet of the red shales. The hills north and south of the Gap, over the mountains on the road from Durham to Gilboa, were of red shale.

31. At the stone arched bridge, five or six miles from Durham, on the road to Cairo, the strata are well exposed. A section of those exposed is given on Plate 6, fig. 1.

32. The grey grits and shales only were seen beyond this, on the road to Cairo, and thence four miles south, and along the base of the mountain to where the road crosses the branches of the creek that rises near Acra, flows south three miles, and then southeast and east and northeast to Cairo. The red rocks were seen in the beds of these branches, and near Acra, and at the crossing of the creek that rises near Acra and

flows north to Freehold. A church and school-house are at this crossing, which is two or three miles north of Acra. Vegetable impressions were occasionally seen in the grey grits between the two main masses of the red rocks.

33. On the road from Pleasant-valley to Windham and Prattsville, the base of the mountain is observed principally composed of grey grits; in the middle, reddish and chocolate-colored rocks predominate; toward the head of the valley, the thick-bedded grey grits abound, and red shales form the higher hills, capped in some places on the high peaks by conglomerate of the coal formation. This distribution of the red and grey rocks is general in the Catskill division, and corresponds with Nos. ix. x. xi. xii. of Prof. Rodgers' Reports in Pennsylvania.

34. Between Prattsville and Delhi, the rocks, when seen in place, were principally the grey and chocolate-colored grits.

35. The valley of the Little Delaware shows the grey grits; the heights, the red grits and shales.

36. The same characters were observed up the valley of Steel's brook from Delhi to West-Meredith, and up Falls brook to Meredith. Grey grits form the head of the valley by the pond at the head of Steel's brook, on the summit level between the Delaware and Susquehannah; while the hills on each side, and above this summit level, are red grits and shales. A quarry of the thick-bedded grey grit is wrought as a building stone, between Meredith-centre and West-Meredith. This grey grit lies above the lower mass of red grits and shales, and below the upper one. Its strata show the water lines of deposition in the oblique lamination, and indicate the directions of the currents that deposited them. Pl. 6, figs. 3 and 4, illustrate this oblique lamination, which is so strikingly exhibited in the grey grits of this division as to be a common subject of remark by persons who have no knowledge of the cause.

37. At the falls of Falls brook, about two miles from Delhi, a fine section of about one hundred and twenty feet of some of the lower red sandstones and shales of the Catskill division is visible.

38. The valley of Fish brook, three miles below Delhi, exhibits the same arrangement of strata as the preceding in Steel's brook, Falls brook, &c. The red shales overlaid by chocolate-colored grit, and these by the grey slaty grits, were seen near the saw-mill.

39. From Delhi to Walton, the same general characters of rocks and order of superposition were observed.

40. From Walton across to Bainbridge on the Susquehannah, across several deep valleys and over mountains, the same rocks and order of superposition were observed. Near Bainbridge, on the road from Masonville, the strata and fossils of the Erie division were found abundantly. They were perfectly similar to those of the Chemung group, that occur near Red bridge, in the valley of the Sandberg creek, in the Mamakating valley.

41. From Bainbridge up the valley of the Susquehannah by Unadilla, Oneonta, and thence up the Charlotte river to Davenport centre, the rocks of the Chemung group form the

bottom of the mountains; while the Catskill division forms the mass of the mountains, which were crossed in many places, and showed the same order of superposition for its main masses, and great uniformity of character for its subdivisions. Vegetable impressions were rather abundant in the *grey grits* between the two masses of red rocks. They bear some resemblance to the woodcuts Nos. 10 and 6. The fucoidal remains and curved impressions are abundant in *the red shale*. Many of the vegetable remains in the grey grits resemble some species of the *lithodendron*.

42. Red shales abound between South-Kortright and Dr. Marshall's, at the junction of Marshall's brook and Betty's brook, in Kortright, Delaware county. The grey grits predominate in the vicinity of Dr. Marshall's.

43. From Hobart to Roxbury, the same rocks, in the same order of superposition, were observed as have been described.

44. A small section of rocks was taken at Stratton's falls, about two and a half miles southwest of Roxbury. It is represented, though very imperfectly, in fig. 2, of Plate 6. It fails to give, like the original drawing, a graphical representation of the *characters* of the rocks, by having been badly copied.

1. The upper mass is of the grey grit.
2. The middle mass is of the red shale, with oblique laminæ in some of the layers, and laminæ very much bent and contorted in its lower part. This has crumbled away, and left the upper mass overhanging.
3. The lower mass is the red grit rock; and from its hardness, has resisted the action of the water more than the superincumbent shale, and it forms a terrace to the edge of the basin into which the water falls.

45. From Roxbury to Aukville, at the junction of the Dry brook and the Bushkill with the Delaware, and thence over Pine hill and down the Esopus creek to Shokan and Canoe place, the same characters of rocks are observed, namely, two masses of grey and greenish grey grits and shales, covered by red and chocolate-colored and mottled grits and shales.

46. From Walton to Colchester and Holmesville, the mouth of the Willewemock, Shahocton, Deposite, Cannonsville and Walton, the same rocks were observed; the grey and greenish grey predominated, with some beds of bluish grit slate. This last is used for hones, and sets a fine edge. Localities about three miles from the mouth of the Willewemock, and others a mile or two below Cannonsville, have afforded some stones for this purpose.

Numerous overhanging cliffs occur near Colchester, called *rock-houses*, caused by the disintegration of particular beds of the grey grits, leaving other parts of the same rock less susceptible of disintegration to form overhanging cliffs, arched grottoes and small caverns. Some may be seen near Dr. Bassett's house. He had the kindness to show me some of them.

47. From Colchester over the mountain south, down Spring brook,* thence down the Beaver kill to the Willewemock, and up this stream to the mouth of the Little Beaver kill,† the same grey and red rocks so often mentioned occur, the grey grits predominating.

48. On the Little Beaver kill, the mountains are not high like those on the east and west branches of the Delaware, Willewemock and Beaver kill; the bottoms are broad, with good land, and the waters are yellow, tinged with peat and with hemlock bark, and are strikingly different in appearance from the pure limpid streams of the mountain region of Delaware county. The rocks were mostly grey grits, to near Berkeley, where the red rocks formed the surface. These red rocks were frequently seen covered by the thick-bedded grey grit and a conglomerate. Red rocks cap many of the hills; others have a cap of grey grit, or a quartzose conglomerate. The soil is fertile wherever the red rocks form the surface, as they generally do near Liberty and Monticello.

At Monticello, the court-house of Sullivan county stands on a red gritty micaceous shale, similar to that which forms most of the elevated grounds near that town; but several of the swells of land are crowned with a stratum of thick-bedded grey grit and conglomerate twenty or thirty feet thick, and which in some places presents the appearance of enormous boulders, in consequence of the disintegration and removal of most of the stratum. A fine example of this may be seen sixty or seventy rods west-southwest of the court-house. The red rock is visible below, while large fragments of what seem to have been an uninterrupted stratum, and weighing from a few tons to more than a thousand tons, lie scattered around. These masses still show the process of continual disintegration, crumbling away in cavities, and pot-holes as they have been called, but the constant scaling off of the rock can be distinctly seen. These rocks had been described to me as showing the wearing action of running water.

The grey rocks are to be seen overlying the red, one and a half miles west of Bridgeville, on the road to Monticello. Below are the coarse red grits and conglomerate, closely resembling in external characters the red grits of Haverstraw, Tappan, New-Haven, Durham, &c. in the New Red-sandstone formation. Still lower in the mountain towards the Neversink river, one-quarter to half a mile from Bridgeville, the red shale predominates; and still lower, red grits and shales of various degrees of fineness. From Bridgeville to Thompsonville, the grey grits predominated.

The red rocks predominate from Monticello about two miles south, where the underlying grey grits emerge, and form the surface most of the way to the Delaware river. The strata dip slightly to the west-northwest, northwest and north.

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* Trout swarm in all these mountain streams. In the latter stream I caught twenty-five fine trout in forty minutes, and caught my bait of grasshoppers during that time. They made a delicious supper and breakfast for myself and party, including also my family who were with me.

† On Burr's county map of Delaware county, the upper part of Willewemock is called the Little Beaver kill. The latter stream flows from the south and southeast mostly from Liberty township.

Several lines of fault were seen, it is supposed, but they were not traced out. The red and grey grits and shales were observed in several places along the Lumberland turnpike; and as the same beds show themselves repeatedly, while they dip slightly, and more frequently than is due to the irregularities of surface, faults or bendings of the strata must occur. The strata appear successively on the surface, as is indicated in fig. 3, plate 29; and faults as there represented, are the probable cause of the successive appearance of the same strata.

The same order of superposition of the red and grey grits was observed at the head of Halfway brook, and near Toronto lake, and again near Black lake. The coarse thick-bedded grey grit overlies the red grits and shales also between White lake and Monticello.

If coal should be found in workable quantities in New-York, it will undoubtedly be in the high mountain region in the north part of Sullivan, the east part of Delaware, west and northwest parts of Ulster, and the central and south parts of Greene counties, above the upper mass of red rocks from one hundred to five hundred feet.

Topographical and Agricultural Characters.

All the country containing the Catskill division of rocks is mountainous, but it lies in heavy swells of land, rarely precipitous except where streams have cut deep gorges and ravines, and on the eastern and southern flanks of the mountains where they bound the Hudson and Mamakating valleys. Nearly all the more elevated swells of land are capable of tillage to their summits. The mountains on each side of the Schoharie kill are from fifteen hundred to two thousand feet above the valley, and within a few miles rise still higher into broad noble swells of land, susceptible of cultivation to their summits. The soil is porous enough not to wash, and springs of limpid pure cold water abound. The surface is stony and gravelly, but is well adapted to grass, oats, potatoes and barley. Wheat succeeds well for a few years after the land is cleared, as long as the roots of trees and bushes remain to keep the soil light; but after that time, the soil heaves by the frost, and the wheat is winter-killed. The country is admirably adapted for grazing, both for cattle and sheep, and the fine sweet grass and cold springs offer as great facilities for making excellent butter as the world affords. A large proportion of the butter sold under the name of *Goshen butter*, which is celebrated for its superior qualities, is made in the mountain region of Delaware, Sullivan, Ulster and Greene counties.

Ripple Marks.

These were seen on a layer of brown sandstone, on the road from Catskill to the Mountain House, one mile above the toll-gate. If the direction of the current producing ripple marks be perpendicular to the general direction of the marks, the current forming these must have flowed from N. 30° E. to S. 30° W.

Useful Minerals.

The rocks of the Catskill division are exceedingly barren of useful minerals.

Small quantities of copper, lead, zinc and iron ores were seen extensively diffused in a particular stratum of rock, in various parts of Greene, Ulster, Sullivan and Delaware counties, but the stratum was nowhere more than eighteen inches thick. It was generally a calcareous conglomerate or breccia, formed of small masses of limestone, imbedded in a reddish or brownish paste of the underlying shale bed.* Sometimes the rounded nodules are of carbonate of iron, and more rarely of galena, blende, sulphuret of copper, and the green and blue carbonates of copper. Black oxide of manganese in an earthy form was also seen. This stratum, although thin, seems to be coëxtensive with the formation in which it was observed. The underlying shales and the overlying slaty grits frequently abound with vegetable impressions, the original vegetable matter of which is sometimes converted into anthracite, and sometimes replaced by blende, oxide of iron, black oxide of manganese, black sulphuret of copper, or by the blue or green carbonate of copper. Although these materials were observed in several places, as in Franklin, Delhi, Roxbury, Windham, Durham, Monticello, &c., yet no localities were seen where they existed in such apparent quantities as to be of any economical importance.

One of these localities on Gooseberry hill, three-quarters of a mile east of Delhi, in Delaware county, has been called the *Coal mine*. It is a seam of the grey slaty grit, about eight inches thick, containing many imperfect vegetable impressions. In some of these, the original plant is changed to anthracite; in others, it is replaced by earthy black oxide of manganese, by crystalline sulphuret of zinc, by sulphuret of copper (black), or by the carbonate of copper. None of these minerals are in any valuable quantity, and it is difficult even to procure a fair suite of specimens. The upper part of Gooseberry hill is said to be about four hundred and fifty feet above the Delaware, which flows at its base, and is composed of grey slaty grit, some of which splits out in plates one-fourth to three-fourths of an inch thick. Some of these plates have been used for covering the roof of a building, instead of shingles. They are not heavier than the large slates or the common tiles, are indestructible, and impermeable to water. They may, perhaps, be used for roofing at some future time, if they can be got out of regular sizes and shapes, and pierced for nails without too much waste and expense.

Another of these localities of copper ore was examined on the land of Judge Beach of Franklin, Delaware county. Here are the same beds of slaty grit and of shale filled with vegetable impressions, as were observed on Gooseberry hill; also a similar bed of breccia or conglomerate, containing the carbonate of iron, and the blue and green carbonates of copper.

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* This stratum, when exposed to the weather, becomes more or less porous and cellular, from the solvent action of the water upon the calcareous ingredient. Considerable quantities of it are seen scattered over the fields, and it has acquired the name of *firestone* in some of these counties, in consequence of its resisting the effects of common fires, not cracking to pieces. Almost all the common grits of the country, when heated, burst to pieces with loud explosions, or else exfoliate and crumble by heat.

The *Copper mine*, as it is called, in Roxbury, Delaware county, is on the land of Mr. Leonard, on the Beaver-dam creek, about three miles and a half from Roxbury village, on the road to Mooresville. A little copper ore was observed in the beds of shale and conglomerate. Whether the supposed body of ore was expected to be discovered in the bed of shale, or in a vein which appears as a broad fissure in the rocks, is not now known. This "mine" was opened before the French war of 1755, and reöpened in 1827 or 1828. Indications of copper are said to have been very distinct, when last opened, by gentlemen in whom I can place confidence. Scarce any traces of copper are visible among the rubbish of the mine at the present time. The son of the owner informed me that the Germans who came there last to open the mine, some years since, tried the water of a spring from the hill side, and found it to contain copper. He gave their mode of trial as follows: "Water from the spring was boiled down to a small quantity in an *iron kettle*; a silver sixpenny piece was then introduced, and taken out coated with copper." Any one acquainted with the relative chemical affinities, knows this to be impossible, as the copper, if any, would be precipitated by the iron of the kettle. Copper would precipitate silver from solution, but silver would not precipitate copper under such circumstances. Some deception must have been practised, if the above statement of the process be correct.

Another mine, a "silver mine," as it was called, was showed me on the bank of Dry brook, about three miles above Arkville, which is at the junction of the Bushkill and Dry brook with the east branch of the Delaware. A handsome adit has been excavated at the juncture of the grey grit with the red shale, leaving the former rock as a solid substantial *rock roof*. At the end of the adit, which penetrates horizontally some thirty or forty feet, a shaft has been sunk, and it is said that rooms of some size have been excavated in the rock below; but the shaft was full of water, so that nothing more could be examined than the adit. The mineral which is supposed to have caused this excavation, was common pyrites, which abounds at the junction of the grit and shale. It decomposes readily, causing the shale to crumble away by its decomposing action and the crystallizing power of the resulting salts.

Specimens of the black sulphuret, and of the blue and green carbonates of copper *in* the gritty shale containing vegetable impressions, were shown to me from near Delhi, Delaware county. If the stratum from which the specimens were obtained, is of the thickness of two feet, and as rich as the specimens exhibited to me, it would be important for exploration. As the discoverers did not communicate to me the locality, I can form no judgment of its importance.

A "coal mine" has been opened in Sullivan county, about one and a half miles west of Red bridge, which latter place is where the line between Ulster and Sullivan is crossed by the Delaware and Hudson canal. It is a bed of black carbonaceous shale, four and a half to five feet thick, with thin seams of anthracite interlaminated, from the thickness of paper to that of thick pasteboard. The shale contains vegetable impressions. It has been opened on the right bank of the Sandberg creek, about thirty feet deep in the dip of the strata; and a seam of pure anthracite *is said* to occur in the shale, six to nine inches thick. I did not see

this, the mine being filled with water. A shaft has been sunk —— feet, with the expectation of striking the coal at the depth of about one hundred and fifty feet, and of finding it there to be thicker. The strata dip about thirty to forty degrees to the west-northwest, and there is so little *back* to the seam, at such depths as would be of easy drainage, that if a coal bed of *five feet* thick *could* be found there, it is perhaps doubtful whether it could compete successfully with the Carbondale and other coal beds of Pennsylvania. It could not perhaps be drained, without expensive and powerful steam engines and pumps, to a greater depth than two hundred feet, giving a back of about one hundred yards in the direction of the outcrop, or one hundred tons of coal per yard in length of the seam for each yard in thickness.

It is presumed there are no seams of workable coal in this vicinity; still, if there is a coal formation in the portion of the State under my examination, it will probably be found in this region of upturned rocks, and on the highest peaks of the Catskills. From the Shawangunk mountains westward by the mine, the whole series of rocks in this part of the First district are upturned on their edges. The rocks at the mine are one thousand to one thousand five hundred feet above the fossiliferous slaty grits of the Chemung group. These grits abound with the most beautiful fossils, about half a mile east of the mine. At no great distance westward of the mine, the strata become nearly horizontal, conforming to the general position of this series of rocks in Sullivan, Ulster, Greene, Delaware and Schoharie counties.

Some varieties of the grits of the Catskill mountain series are quarried to some extent for *grindstones*, for which some of the strata are well adapted. *Rubstones* or *whetstones* of various degrees of fineness, hardness and sharpness of grit, might be procured, and have been obtained in Monticello, on both branches of the Delaware, and on the Beaverkill and Willewemack river. Grindstones are quarried in Cobleskill and Fulton in Schoharie county.

Some of the shales that crumble by exposure to the weather, would, it is believed, be useful as mineral manures or marls on the lighter soils of this region. They contain more or less lime and some pyrites, and by decomposition would form a portion of sulphate of lime or gypsum. There are numerous strata of red, grey and black shales in this formation, that crumble easily, and when quarried, require nothing more than exposure to the frosts and weather to prepare them for strewing over the soil.

Beautiful building stones have been quarried from the Catskill mountain series in many places, which come out of the quarry in regular layers, from six to fifteen inches thick, with faces along the joints of the rock perpendicular to the layers, and smooth as if sawed. They have been particularly noticed in Meredith and Kortright in Delaware county, and near the mouth of the Willewemack river in Sullivan county.

Fossils.

These will be described in palæontological part of this work.

II. ERIE DIVISION.

SYNONIMS. *Lower part of the Catskill mountain series. Third greywacke* of EATON. *Formation No.* 8 of Prof. RODGERS, (*Olive slates*); *Skaneateles shales, Dark grey fossiliferous shale, Compact calcareous blue shale, Olive shale, Ludlowville shale, Encrinal limestone, Moscow shale, Apulia and Sherburne shales, and Cazenovia group.**

This division of rocks underlies the Catskill division, without being separated by any very obvious line of demarkation in the First Geological District. The rocks of these divisions graduate into each other in their characters in the First district, and have been described in former geological reports as the Catskill mountain series.† In other parts of the State, where fossil remains abound in these rocks, the line of demarkation is more easily recognized. The rocks of the Erie division form the base, and a part of the mass of the Catskill mountains. They also occupy the top of a part of the Helderberg mountains. They range from the Delaware river, near Carpenter's point, along the west side of the Mamakating valley‡ to Kingston; thence on the west side of the Hudson valley nearly north, at a distance of a few miles from the Hudson to the south line of Albany county, whence they bear away to the northwest on the Helderberg mountains, at a higher level than in other parts of their range; and finally westward, along the southern side of the Mohawk valley, and occupy most of the south part of the State between the Erie canal and Pennsylvania.

The rocks of this division consist of sandstones distinctly stratified, often fissile, and highly indurated, of grey, greenish grey, olive, black and brown colors, called by many persons *greywacke*§; and of slates and shales of similar colors.

The Erie division in the First Geological District, consists of the following groups, viz:

1. Ithaca and Chemung group.
2. Hamilton group.
3. Marcellus shales.

The Portage group, Genesee shales and Tully limestone, of the Erie division, if they exist in the First district, have not been recognized as distinct strata.

Some of the rocks of the Erie division are upturned at a high angle southwest, west and northwest of Catskill, near where a fracture parallel to the main axis of disturbance crosses the Kaaterskill and Catskill creeks; and also near Port Jervis, on the Delaware; and thence by Cuddebackville to Red bridge and Ellenville, where another axis of disturbance crosses the Delaware and extends through the Mamakating valley. The dip, except in these and

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* Final Report of Third District, by L. VANUXEM, p. 150.

† Vide Geological Reports of New-York, 1840, p. 527; 1841, p. 77.

‡ The Delaware and Hudson canal passes through this valley.

§ *Third greywacke* of Prof. A. EATON.

perhaps some similar localities, where some derangement in the position of the strata has been effected on or near the lines of disturbance, is very slight; being, in the valley of the Delaware, to the northwest and west; in the Mamakating valley, to the west-northwest; on the Helderberg mountains, to west and southwest; and on the south side of the Mohawk valley, to the southwest and south.

The rocks of the Erie division occupy, in the aggregate, a thickness of several hundred, probably two thousand feet. They extend far to the west and southwest, and form the surface rocks over at least one-third part of the States of Ohio and Kentucky, lying between the Cliff limestone and the Coal formation.*

Joints traverse the rocks of the Erie division, and the vertical seams are more smooth and regular in these rocks than in any other parts of the geological series examined. The directions of the two main systems are N.N.E. to S.S.W., and E.S.E. to W.N.W.

The only rock of the Erie division that is worked extensively for economical purposes, is a stratum of flagging stones. It has various local names, as the Saugerties, Kingston, Coxsackie and North-river flag-stone. This stone forms a stratum which is generally about two feet in thickness, and can be split out in slabs of from ten to one hundred square feet, and from one to six inches thick. The rock is traversed by joints that divide the slabs about perpendicular to their layers, and smooth as if cut by a saw. There are two, sometimes three sets of these joints which divide the rock into regular blocks, and facilitate the labors of the quarrymen. Similar joints traverse the whole rock series under examination. These joints are remarkable for their smoothness, and are nearly uniform in their directions.

The stratum of flag-stone is from seven hundred to one thousand feet above the Helderberg limestone series. It is quarried in Sullivan county, for the supply of that and Orange counties; but the principal quarries are in Ulster, Greene and Albany counties. It has been estimated that fifty loads per day pass through Kingston to the landing for five months in the year, for shipment to New-York and other places, which would give about 900,000 feet as the amount shipped from Kingston. Saugerties, Coxsackie, Bristol and New-Baltimore, send in the aggregate about 2,500,000 feet more. The aggregate amount of flagging stone quarried in Sullivan, Ulster, Greene and Albany counties, may be supposed to be about 3,500,000 feet per annum.

The principal quarries near Kingston are owned by Judge Hasbrouck, who leases them to quarrymen for five dollars per thousand feet; and as each square yard will give, on an average, from fifty to seventy feet, each acre may be conceived to yield three hundred thousand feet, and thus give the proprietor a clear income of fifteen hundred dollars per acre, from land which was purchased a few years since for one dollar per acre.

This rock ranges from the Delaware river, through Sullivan and Ulster counties, nearly parallel to the Delaware and Hudson canal, to within four or five miles of Kingston; thence

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* The Catskill division, or Old Red-sandstone, is either wanting, or so slightly developed in those States as not to have been recognized. The rocks of the Erie division are extensively developed in several of the Western States.

nearly parallel to the Hudson, to opposite Saugerties; thence around the Catskills, to the mountains east of Rensselaerville; and thence westward through Schoharie county, a distance of about one hundred and forty miles, without reckoning the winding line of outcrop, in consequence of various irregularities of the ground.

The flag-stone rock, like many others of this series that do not disintegrate by exposure to the weather, frequently forms terraces; and in many places it is but slightly covered by soil, or by a thin stratum of rock which is similar to this, except that it does not split as regularly. The quarrymen select such places as present the least obstruction to working, and are nearest to good roads leading to the Hudson river. The strata lie nearly horizontal, pitching very slightly to the northwest from the Delaware to Woodstock,* then westward to east of Rensselaerville, then southwestward and southward to Summit in Schoharie county.

The flag-stone stratum was seen in many places in Albany and Greene counties, where it has not been worked. This stratum has been, and is still, extensively worked for flagging stone in Coeymans in Albany county. This stone is not confined to the hills in which it is quarried, as is generally imagined by the people there, notwithstanding the numerous facts continually presented to eyes that do not see; but this, as well as each of the other particular strata, occupies a uniform and determinate position, and by careful examination can be found, and opened in every hill along its range that is high enough to be intersected by its plane. The quantity of this rock is so great that it cannot be exhausted. It has been traced, exclusive of the sinuosities produced by valleys intersecting its plane, a distance of one hundred and forty miles in the First geological district, and it undoubtedly underlies all the country that is occupied by that portion of the Catskill and Erie divisions that overlie this rock. The principal flag-stone quarries in Coeymans are those of Mr. William Briggs and Mr. C. Brown.

A bed of blue crumbly soft shale underlies many of the flag-stone quarries, and slaty grits with water lined laminæ of deposition overlie, where all the strata occur together. Remains of plants, apparently of terrene plants, sometimes carbonized, sometimes pyritized, and sometimes as mere impressions, are common in the strata immediately overlying the flag-stone stratum, and are found also in the flag-stone. One fossil seems to be peculiar to the flag-stone stratum. It seems too indistinct for determination, but is cylindrical in form, of about the diameter of a pipe stem or a quill, lying in graceful curves which frequently intersect, sometimes like a flattened helix. They may be seen occasionally in the flag-stones from the quarries in Ulster, Greene and Albany counties, that are laid for side-walks in Albany, New-York, and various towns where they have been used. My attention was first called to these curious markings by Prof. L. D. Gale, before the commencement of the geological survey of New-York.

The Erie division of rocks is included in the section from the South mountain, near the Mountain House, to the stone bridge of the Kaaterskill,* between 128 and 134.

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* From the Delaware to Wawarsing, the strata next the valley of the Delaware and Hudson canal are all upturned at a high angle, and a flag-stone stratum throughout this distance is upheaved in the same way as the adjacent rocks.

The rocks of this division may be examined minutely in very numerous localities, but slight examinations only of them have been made in the First district, in consequence of their not exhibiting so many *prominent* points of economical or scientific interest as some of the others.

Near Port Jervis, on the Delaware, and thence to Ellenville, the rocks of this division are more highly indurated than in most other places, and seem almost trappean in some localities.†

Some of the strata can be well examined on the Sandberg creek, one and a half miles west of Red bridge, on the line between Sullivan and Ulster counties. It is one of the few localities where fossils were observed to be abundant. *Avicula chemungensis* (Vanuxum), *A. tricostata* (V.), *A. flabella* (V.), *Cypricardita chemungensis* (V.), and *Delthyris prolata* (V.), were found in the rocks on the Sandberg creek.

The rocks can be well examined by following up the valleys of the Good Beerkill, west of Ellenville; the Rondout, west of where it enters the Mamakating valley; the Mombockerkill, in Rochester; the Esopus, northwest of its junction with the Mamakating valley in Marbletown; the Saghkill, in Kingston; and the Plattekill in Saugerties. These localities are in Ulster county. The Marcellus shales are rarely seen in the valleys of the streams alluded to, as it is mostly covered by the alluvial and quaternary deposits of the valley. Concretionary iron ore, but very impure, was observed in the rock near Ellenville and Wawarsing.

In Greene county, the strata above the Marcellus shales are well exposed in the ravine along which the small stream flows from the west, near the turnpike leading from Catskill to the Mountain House. The strata exposed in this ravine are embraced in No. 132 on the detailed section‡ from the south mountain, to the stone bridge across the Kaaterskill.§ They may also be seen along the banks of the Catskill creek, from Madison to Cairo; and on the Po-

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* Vide section, pp. 303, 315, of this volume — Chapter IV. CATSKILL DIVISION.

† A beautiful section of the rocks is exposed to view along the line of the Delaware and Hudson canal, in the valley of the Delaware, between the mouth of Lackawaxen creek and Port Jervis. In passing east-southeast along this route, the observer is continually descending in the geological series, until he arrives at the primary rocks of the Pochunk mountains. Within a quarter of a mile of Port Jervis, the rocks of the Erie division become very dark colored gritty slates of great weight, very siliceous and compact, so as in some instances to resemble some varieties of trappean rocks.

There are several reasons to induce an examination in detail of this vicinity by those who may have the necessary acquirements and opportunity, viz:

1. The apparent action of heat on some of the strata.
2. The neighboring local derangements of the strata.
3. The mural escarpments on the southern sides of the upheaved hills.
4. The probability of its being a continuation of one of the transverse lines of disturbance crossing the Highland mountains, and extending westward across the white metamorphic limestone region of Orange county.

The time employed on the geological survey, was necessarily so much occupied in economical geology, to satisfy individuals and public opinion, that the great problems of physical geology capable of solution, and some of which might, perhaps, have been solved by pursuing a different course, remain for future investigation.

‡ Vide the section, p. 303 to 305 of this volume.

§ This is sometimes spelled Caterskill, and Katerskill, but the other is most common.

tack creek, between the townships of Cairo and Athens, and in the beds of the streams in various parts of Greenville, and in the west parts of New-Baltimore and Coxsackie.

The finest exposure of these strata was observed in Coeymans, Albany county, along the banks of the Hawnakrans kill and its branches, as far up in the series as the flag-stone stratum. The strata are not all exposed in the bed and banks of the stream, but they may be easily traced out on the table lands north of it, on the road to Clarksville, on which they are exposed in successive broad terraces with steep escarpments, offering every facility for minutely examining their fossil contents.* The south part of Bern, and nearly all the townships of Westerlo and Rensselaerville are occupied by the strata of the Erie division. The Marcellus shales are largely developed, overlying the limestone of the Helderberg division in Coeymans, Bern and Knoxville, but fossils are rare. In some places it is so black as to have led to search for coal. The Hamilton, Ithaca and Chemung groups, occupy most of Rensselaerville and Westerlo, and a part of Bern.

More than one half of Schoharie county is occupied by the rocks of the Erie division, and they are beautifully exposed to observation in very many places. The roads from Middleburgh bridge by Byrnville to Summit; from Hyndsville over the mountain by Richmondville, to Summit; from Summit to Jefferson Academy; from this last place to North-Blenheim, and thence to Gilboa and Strikersville, offer fine opportunities for examining the strata, but they are better exposed in the neighboring ravines, and at the numerous falls on the small streams. Fossils were seen in many places on these routes by the road sides in the rocks in place, but they are rarely abundant as they are in the same rocks farther west.

The valley of Schoharie creek between Middleburgh bridge and Gilboa, also offers fine opportunities for examining these strata; and the valleys of the small streams that flow into the Schoharie kill offer still better opportunities.

Above the Helderberg limestone series, south of Hyndsville, in Schoharie county, a shale or slaty crumbling grit was observed, which is a part of the Marcellus shales.

Above this, a series of rocks occurs, composed generally of fissile sandstones, and contains many strata abounding in testacea of various species; also fucoids and terrene plants. This is the Hamilton group of Prof. Vanuxem.

Shells were seen in many places in the grits and gritty shales, betweenSummit and Jefferson Academy, especially on the high grounds and on the tops of the hills. They are particularly abundant about one mile north of Jefferson Academy. There are several strata abounding in marine testacea, between Summit and Richmondville, and the same strata are crossed on the road thence over the mountain to Hyndsville. Other strata abound in plants. The shell strata may also be seen on the road from Summit to Byrnville, in the town of Fulton.

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* This is the northeastern extremity of that formation; and each stratum, at its outcrop to the north and east, occupies a terrace of greater or less breadth. In many localities, the greatest facilities are thus presented to the collector of fossils, to procure numerous fine specimens of these medals of a former epoch, and also to the quarryman to quarry extensively, with little or no expense in uncovering the particular strata of rock that may be desired.

Limestone containing carbonate of iron is common, and in its unchanged state it does not show its fossils distinctly, but by weathering loses its carbonate of lime, and leaves a yellowish mass of spongy impure limonite, filled with the impressions of shells. Loose blocks of this rock were seen in abundance one mile north of Jefferson Academy, Schoharie county. Fucoids and the same terrene plants* were observed here, as on the descent of the mountain north of Summit.†

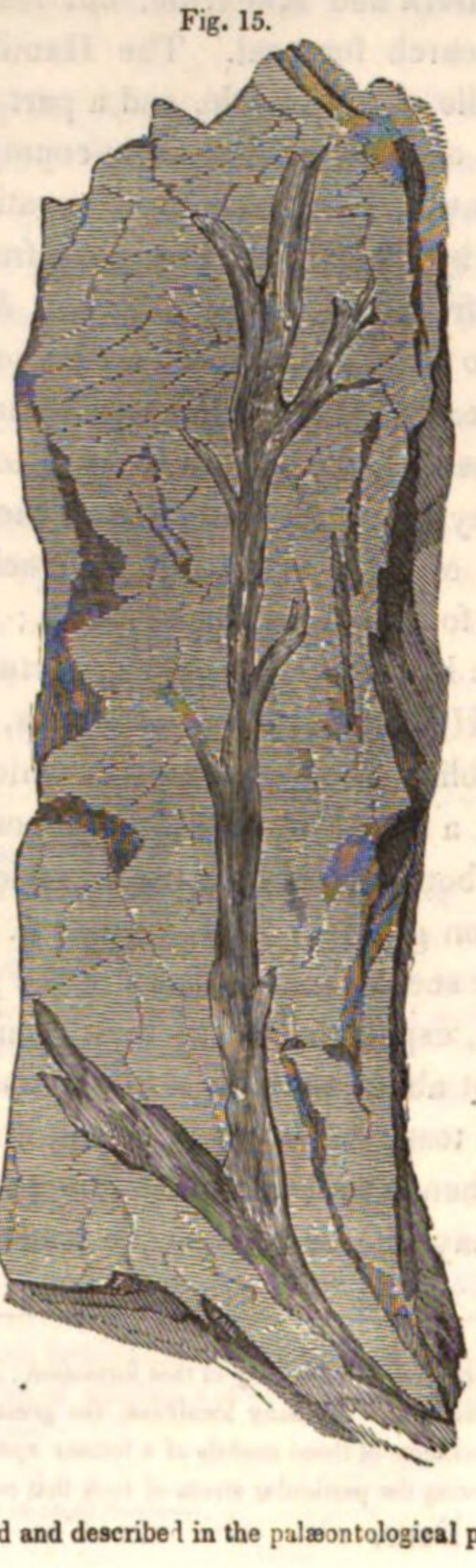
The grey grits by the falls at the tannery, at North-Blenheim, contain fossil shells. They

* Some of the plants referred to are figured in Prof. Vanuxem's Report, pp. 157, 161.

Fig. 14.



Fig. 15.



† The various fossils of the different divisions will be figured, named and described in the palæontological part of this work.

were first observed by Prof. Vanuxem, who found their stratum about six inches thick. Several localities were observed where many species of fine shells may be obtained, in the bluish and brownish gritty shales on the road from North-Blenheim to Gilboa.

The joints of vertical planes intersecting the rocks are remarkably well characterized in the Hamilton group, near North-Blenheim post-office.

Limestone containing fossil shells is said to occur on the summit of the isolated mountain called the Roman Nose, in Schoharie county. This position would be in or above the Hamilton group, and at or near the position of the Tully limestone. I did not examine the locality.

Septaria occur abundantly in the Marcellus shales in Schoharie county. Mr. J. G. Gebhard junior, found them near Middleburgh and Mann's valley. They are of various sizes and shapes, generally of a flattened ovoidal form, from a few inches to three or four feet in diameter. Pyrites in brilliant drusy crystals, and a little pyritous copper were observed in the septa of some of those near Mann's valley and Cobleskill. The slate is very black, and overlies the limestone,* and excavations in search of coal have been made near Cobleskill, Punch brook and Middleburgh. Carbonaceous matter is diffused in minute particles, and interlaminated in extremely thin films; but it is superfluous to add that there is no hope of finding coal in it.

Various fossil remains have been found by Mr. J. G. Gebhard junior, in this black slate, which will be figured and described in the palæontological part of this work.

The Catskill and Erie divisions form the high mountain region of Greene, Ulster, Sullivan, Delaware and Schoharie counties. The streams flow in deep valleys, which seem to have been formed by erosive action; since the strata, in most instances, correspond on the opposite sides of the valleys. There are some exceptions where there are indications of great fractures and rents of the strata, which traverse the country for many miles, and give direction to the streams. The soils on this formation are generally good; but as the country is very heavily timbered, much time, labor and expense, are required to bring them into use.

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* Near Cobleskill village, the black slate containing septaria is overlaid also by a bed of limestone, but this may belong to the Helderberg division. The rock was not traced to find its connection with other rocks.

III. HELDERBERG DIVISION.

This division embraces a series of limestones, varied in mineralogical character, in chemical composition, and abounds in fossil remains. It contains subordinate beds of shales, slates and siliceous grits. It skirts the group of rocks last described, in a parallel zone, and underlies them, it is supposed, through their whole extent.

This formation extends in the district under examination, from Sharon springs in Schoharie county, by Schoharie, to the northeast part of the Helderberg mountains; thence southeast, to near New-Baltimore; thence southwardly, by Catskill and Saugerties, to Rondout; thence up the valley of the Rondout, by Rochester, Wawarsing and Ellenville; thence on through the Mamakating valley, by Cuddebackville, to Carpenter's point on the Delaware. At the latter place, it passes out of the State of New-York into New-Jersey, and crosses the Delaware into Pennsylvania, at the Walpack bend of the Delaware, according to Prof. Rogers.* Becraft's mountain near Hudson, and Mount Bob, a few miles to the northeast, are outliers of this division.

This formation varies much in its subordinate beds in different localities, particular beds being either entirely wanting, or replaced by others; but its fossil contents are nearly uniform. Mr. J. G. Gebhard junior, of Schoharie, who was the assistant for Schoharie county, has examined this group with much attention for several years, and he has a more perfect collection of the fossil remains of its various strata than any other individual.

The lower strata of this division of rocks consist of various beds of common and hydraulic limestones, varying much in thickness and in quality, even in contiguous quarries. These strata sometimes rest unconformably upon the Hudson slates, as at Lawrence's quarry on the Rondout, opposite Wilbur; sometimes conformably on the Shawangunk grit, (Millstone grit of Eaton,) as at Rosendale and Lawrenceville on the Rondout; sometimes on the red and variegated shales and grits that overlie the Shawangunk grits, as at the High falls of the Rondout, in Marbletown; and upon the shales and grits of Schenectady and the north part of Schoharie county (Hudson slate). These facts and others connected with the superposition and derangements of the Helderberg division are illustrated in Pl. 26; Figs. 3, 4, 5 and 6 of Pl. 25; Figs. 4, 5, 6 of Pl. 24; Fig. 1 of Pl. 12; Fig. 15 of Pl. 9; Figs. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 of Pl. 8; Figs. 1. 2, 3, 4, 5, 6, 9 of Pl. 7; Fig. 7 of Pl. 6; Figs. 2, 3, of Pl. 39; Figs. 14 of Pl. 38; Figs. 8, 9 of Pl. 27.

The rocks of this division form a mass of some four hundred feet in thickness, composed of various strata of limestone, each characterized by its fossils and mineralogical characters, and interstratified with shales and grits; but limestone is the predominating rock. The rocks of this series occupy a great area in the central part of the State; and each stratum, in conse-

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* Vide Prof. Rodgers' Second Annual Report on the Geological Survey of Pennsylvania, p. 56.

quence of being nearly horizontal, forms almost the only rock over large tracts of country; but in the Helderberg mountains, and on the eastern and southeastern outcrop of the strata, the whole series can be examined within a very short distance, and the superposition of nearly all the rocks of this series may be seen by following up the ravines. In consequence of these rocks being so well developed on the Helderberg mountains, and their forming a natural group, strongly marked in their lithological and palæontological characters from the strata lying above and below them, the term of *Helderberg division* is used to designate them.

Mr. Vanuxem has, very properly in my view, divided this division into several groups, to which he has given particular names, indicative of localities where they can be examined easily, or where they are most largely developed, or best characterized by their lithological characters or organic contents, or peculiar fossils.

Some of the rocks that are largely developed in masses of great thickness and extent in the central and western parts of the State, and the position of which is such in the order of succession as to place them within the limits of the series under consideration, diminish in thickness from west to east, so as to have wedged out and entirely disappeared, or to be very thin, and not to be found except by careful investigation. Again, there are others well developed in the east part of the State, that gradually thin out and disappear as we trace them to the west. I am disposed to adopt the names that Prof. Vanuxem has proposed for the rocks embraced within the limits of this series in the First Geological District, *as subordinate members of a great natural group*, and which is seen to such advantage, well developed in the Helderberg mountains in Albany and Schoharie counties, and to which the name of Helderberg division is now applied.

The following are the principal masses of the Helderberg division in their order of superposition.

No.	Members.	Synonimes.
1	Corniferous limestone.	Seneca limestone, Selenurus limestone of Gebhard.
2	Onondaga limestone.	Grey sparry limestone.
3	Schoharie grit.	Schoharie layers, Shell grit.
4	Cauda-galli grit.	Cocktail grit of Dr. Eights.
5	Oriskany sandstone.	White sandstone of 1838, No. 7 of Pennsylvania report.
6	Delthyris shaly limestone.	Scutella limestone, Sparry limestone of Gebhard, Delthyris shales, Catskill shaly limestone.
7	Pentamerus limestone.	No. 6 of the Pennsylvania survey.
8	Water limestones.	Tentaculite limestone, Water limestone, Hydraulic limerock of Eaton.
9	Pyritous slates.	

The following section was given by Mr. J. G. Gebhard junior, but the above is believed to be most accurate from repeated observation.

1. Grey calcareous sandstone, abounding with fossils.
2. Corniferous limestone, containing many layers and courses of nodules of chert and hornstone.
3. Cocktail grit of Dr. Eights, characterized by Fucoides cauda-galli.

4. Sparry limestone,* highly crystalline in texture, and containing many fine fossils.
5. Shale.
6. Pentamerus limestone, capped by a thin siliceous stratum containing many fine fossils.
7. Tentaculite limestone.
8. Water limestones.
9. Pyritous slates.

There may be two or three subdivisions introduced with propriety, in consequence of marked changes in the organic contents, as well as in the mineralogical characters of masses lying between some of those above mentioned. The second Pentamerus limestone is between the Delthyris shale and the Scutella limestone.

The Scutella limestone was so named by Professor Vanuxum in consequence of a fossil that abounds in it, and is characteristic of the rock, that has some resemblance in form to some of the scutellæ. It was so called as a matter of convenience merely, to designate the rock. The fossil referred to is the pelvis, almost discoidal in form, of a species of encrinite.

The limestone in which this fossil occurs is a grey, and in some places reddish, crystalline limestone, replete with encrinal and testaceous remains. The fossils are all crystalline carbonate of lime; and those that have been called scutellæ, are white or red, and highly crystalline, and from their size and prominent colors, attract the attention of observers when travelling along the road. These fossils are from one to two inches in diameter.

The "Delthyris shales" convey by their name an erroneous idea of their nature. They are slaty, compact, or finely granular grey and blue limestones, abounding in various testacea and coralline remains.

Economical applications of the materials of this division.

The materials in the Helderberg division that are applicable to useful purposes, are,

1. Limestones, for building stone.
2. " " marbles.
3. " " common lime.
4. Cement rock for hydraulic lime.
5. Pyritiferous slate, for alum, copperas and sulphate of lime.

Building stones and Marbles.

The Pentamerus, Tentaculite and Water limestones, all afford fine building stones, which can be procured in blocks of large size, perfectly solid, and free from cracks or flaws, in many parts of the range of these rocks, which extends in a curved line one hundred and forty miles

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* This limestone, called by Mr. Gebhard *Sparry limestone*, is very different in aspect and geological position from that called by this name by Prof. Eaton, and is the Scutella limestone, the upper member of the Delthyris shaly limestone.

in the First district. Through this long distance, the outcrop of these rocks is not concealed more than twenty or twenty-five miles, and this only at intervals of a few miles, where they are covered by the quaternary deposits of the Mamakating valley, between Rochester and the Delaware river at Carpenter's point.

Numerous quarries may be opened near to water transportation, for the supply of the New-York and other markets, from the "High Rocks" above Kingston point, by Rondout, Eddyville, Rosendale, Lawrenceville, Highfalls, Rochester and Wawarsing, and which shall be within a few rods to one half mile of canal or river navigation.

Strata of these rocks are from a few inches to three feet thick, from which the stone can be taken out in regular and sound blocks of almost any desired size.

These stones vary from ash grey to black, and present almost every shade between these colors. Blocks may be selected of uniform texture. Stones can be procured here as handsome as at the celebrated Amsterdam quarries, where so many are quarried for the Erie canal, and for the Albany, Troy and New-York markets.

The blocks from some of these beds are susceptible of a high polish, and will undoubtedly make as valuable black and dark colored marbles, as those at Glensfalls and Swanton.

Some of the strata will yield fine and beautiful marbles, black, grey, and veined like the "Egyptian," but with *white* and *grey* veins instead of *yellow*, and perhaps more difficult to work.

Some are also fitted for building purposes, as for public and private edifices, bridges, aqueducts, and canal locks. The layers, or individual strata, are frequently seen two, three, four and five or six feet in thickness, and perfectly sound, in large blocks. All the strata of this series, as well as those above and below, are intersected by two main systems of joints nearly perpendicular to each other, and these parallel joints are frequently within the distance of a few feet. In consequence of these natural divisions, the rock is easily quarried in large blocks from five to fifty tons weight, and these are easily wedged into blocks of the sizes required for buildings or other purposes.

There is an extensive quarry about three miles from Coxsackie landing, on the road to Greenville, owned by Mr. Melantho Bellows. Blocks have been quarried at this place for the weigh-lock in Albany. The rock is one of the strata of the Water lime, or the lowest of the Pentamerus limestone, near the base of the Helderberg limestone series. The stone is hard and more expensive to dress than some others, but it is a material that will stand unchanged for any finite period of time. Blocks of almost any required size may be easily procured.

Another quarry that is extensively wrought for heavy blocks for the Erie canal enlargement, is on the farm of Abram Verplanck, esquire, in Coeymans, about four miles from the landing at Coeymans and New-Baltimore. As good and as large blocks can be procured at this quarry as at the one before mentioned; and while the stone seems to be as indestructible as that of the other quarry, it has the advantage of being much more easily dressed and quarried. It was said to me, that had the contractor for the lock stone known of this quarry, on commenc-

ing the fulfilment of his contract, he would have been enabled to clear twenty thousand dollars more on his contract than he would now be able to do.* This quarry is in one of the upper beds of the Helderberg limestone series, viz. the rock that in Schoharie county is burnt for lime, and that contains the several species of the *Cyrtoceras* (the Onondaga limestone). The strata dip about one foot in forty or fifty to the southwest.

Lime and Hydraulic cement.

Quicklime is made from particular beds of every part of the Helderberg series. It is not made in such quantities as to deserve particular notice, except in Albany, Schoharie and Ulster counties. In Schoharie county, it is supposed that about twenty thousand bushels are made annually for manure, building, and for the supply of Delaware county, which it is believed has no beds of limestone suitable for burning; and Albany county furnished thirty to forty thousand bushels annually to Albany and other markets.

Between Wilbur and Eddyville are four limekilns for making quicklime, belonging to Mr. Hamilton and Mr. Dubois. These kilns are supplied with limestone from strata that lie between strata of cement rock. They are on the bank of the Rondout, and offer every facility for easy transport. These and other kilns in Ulster county probably make forty thousand bushels per annum.

The beds of limestone that yield hydraulic cement are extensively worked in the vicinity of Kingston, Rosendale, Lawrenceville and Highfalls. The following is a list of the principal kilns:

Lawrence & Austin.....	2	kilns	between Kingston landing and Eddyville.
Benjamin & Co.....	2	"	and steam mill for grinding.
Taylor & Little.....	2	"	between Kingston landing and Eddyville.
Thaddeus Phelps.....	3	"	" " "
McNulty & Chapman...	2	"	" " "
Whiting & Weeks.....	2	"	" " "
Dusenbury	1	"	at Eddyville.
White & Co.	15	"	between Kingston and Rosendale.
———	2	"	at Bridgeport, near Rosendale.
Flint	3	"	one and a half miles north of Bridgeport.
Lawrence & Co.....	13	"	at Lawrenceville, near Rosendale.
O'Neil	2	"	on Coxen-clove creek, southwest of Rosendale.
———	2	"	on Rondout about Lawrenceville.
Isaac Hasbrouck.....	4	"	High falls of Rondout.
Thomas D. Robinson....	2	"	one-fourth mile above Highfalls.
———	3	"	four or five miles above Highfalls.
Total number	60		

* It is customary to pay no regard to the original bedding of the stone, when laying it up in buildings and other structures; but where it is to sustain a great pressure, this is a highly important consideration. I have often seen columns for buildings and store

There are sixty kilns for the manufacture of cement, each of which, on an average, may be estimated to yield forty barrels per diem, when in operation. Most of the kilns are in operation as perpetual kilns, during the warmer season of the year, when the Hudson river is navigable. In June, 1840, it was estimated that six hundred thousand barrels of cement would be sent to market from those kilns during that season. It was said that five hundred thousand barrels were manufactured there during the previous season. The Croton water works, and the various government works, consume large quantities of this cement; and its use for various hydraulic works, and for cisterns, wet cellars, etc., cause a continually increasing consumption. It is shipped to all our Atlantic ports, and to the West Indies.

White's quarries and kilns are the most numerous, and turn off about six hundred barrels of cement per diem. Mr. White contracts with the quarrymen to quarry and burn the stone for twenty-five cents per barrel, while he furnishes the fuel, (dust anthracite from skreened coal,) delivered at the kilns, removes the cement to the mills, grinds and barrels it.

The kilns are built something in the form of a high furnace, except the hearth, which has a sloping sole of forty to forty-five degrees from the back of the kiln to the floor of the drawing arch at the base. These kilns are kept in perpetual operation several months, and are charged like a high furnace. The dust anthracite and broken cement rock are charged, as usual in perpetual kilns, twice in twenty-four hours, each charge being introduced in successive layers at the top of the kiln, after a quantity of cement has been hauled out from the sole of the kiln, into the shed next the drawing arch. About a ton of dust anthracite is used daily in a kiln that burns forty barrels per diem. The kilns are usually built double or triple, that is, two or three, or even more, are built in one stack, one set of men being sufficient to attend several kilns. Some have roofs over them, others have not, but *all* have sheds over the drawing arches, in consequence of the necessity of protecting the cement from the weather.

At Lawrence's works there are two blocks of kilns, one containing six kilns and the other seven. The quarries, kilns, mills for grinding, and barrel factory, are almost contiguous, and on the banks of the Delaware and Hudson canal. These works economize labor and transportation more than any others I have seen connected with the cement manufacture, and they turn off from fifteen hundred to three thousand barrels of cement per week.

The cement business of Ulster county gives direct employment to at least seven hundred men, as quarrymen, burners, teamsters, millers, packers, coopers, and those engaged in transporting the article to New-York; and indirectly it affords employment and profit to many others.

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fronts, which in their natural position in the earth were in horizontal layers, and in the buildings the planes of stratification were vertical. The pressure was then in a direction perpendicular to that to which they had been subjected before. It is often the case that these masses begin to scale off the sides and crumble away, until the structure tumbles down, or the defective masses are replaced by better materials. This principle is almost universally neglected in the United States. I have seen some buildings constructed at great expense that are in a state of rapid decay from a neglect of this principle, which is recognized by every engineer that deserves the name, and *ought to be* by every architect.

When making the reconnoisance, soon after the commencement of the geological survey, this business had but commenced, and there was no cement manufactured on the Rondout, except at Lawrenceville, and there but few kilns were in operation. It was not then known to the inhabitants that the cement rock was abundant, except at and near those quarries, until some of them were then informed of its inexhaustible quantities. Even now few are aware of the great extent of this rock, and still fewer understand how to trace out the situation of favorably located new quarries.

The cement beds and overlying limestones, up the valley of the Rondout, (and in fact north to New-Baltimore,) are very much broken up, upheaved, overturned even, and contorted very much. The facts connected with this derangement of the strata have a practical bearing, in exposing the cement beds so as to render them capable of being worked with the minimum expense, in a multitude of localities where they would not otherwise be accessible.

Derangements of the rocks of the Helderberg division.

Between Kingston and Wilbur, the strata are very much broken and contorted, having been traversed by numerous extensive faults and disruptions; and where these have not occurred, the strata are bent and contorted in a remarkable manner. At some of the quarries on the hill near Wilbur, the strata approach to a horizontal position, but they bend down more and more, until they pitch under the Rondout river, at angles of forty to fifty and sixty degrees. On the opposite shore, the same strata show their broken ends on the mural precipice that rises from the water, and their dip is slight, and in the same direction as the more moderate dip at the quarries on the top of the hill. The river here flows along a line of fault (Vide Pl. 7, fig. 6).

At White's quarries, which are numerous, the rocks generally dip to the east-southeast, at angles from thirty-five to forty-five degrees; but there are some, where the strata are nearly vertical; in one they are reversed, and dip seventy-five to eighty-five degrees to the west-northwest, and in one they are nearly horizontal (Vide Pl. 7, fig. 5). There are generally two or three strata of the cement rock with seams of calcareous slate or shale between, varying from four to twenty feet thick; and again, other strata of the cement are separated by strata of limestone twenty or thirty feet thick. Each hill seems to have been formed by the strata cracking in parallel lines, and then being upheaved or down-heaved on one side, or on a diagonal line, while the opposite side or angle remained fixed (Vide Pl. 7, fig. 4; Pl. 8, figs. 1, 2, 3, 8; Pl. 26, fig. 7). The same strata are seen in each hill, and in the same order of succession, except in some few cases of overturn, where the strata are reversed (Vide Pl. 8, fig. 7).

On Pine mountain, between Rondout and Kingston point, is a high cliff of limestone overlying the grey grits of the Hudson slate series. The strata of these grits are from eight to twenty inches thick, homogeneous in texture, and divided into blocks by joints, which traverse the rocks in parallel directions with regard to the planes of stratification. The strata of this rock here dip to the east-southeast at angles of forty to sixty degrees. The overlying

limestone along the brow of the hill and at the cement beds of Hasbrouck's quarries* dip about eighty degrees west-northwest, and this dip continues nearly uniform along this line of upheave to the "High rocks" above Kingston point (Vide Pl. 8, fig. 7).

At Lawrence's quarry, opposite Wilbur, at the southwest end of the limestone hill on the right bank of the Rondout, is a fine exposure of the different strata, and the Hudson slates are seen *unconformable*, below the limestone (Vide Pl. 26, fig. 1).

The following is an approximative section of the rocks at the south-southwest end of that hill:

1.	Fossiliferous limestone like the "middle limestone of Becraft's mountain" (*d*)		60 feet.
2.	Fossiliferous limestone, different from the above, and containing hornstone (*c*)		50 "
3.	Compact dark grey limestone, (contains encrinal spines and the pentamerus)		34 "
4.	Clouded striped limestone	(*b*)	20 "
5.	*Cement rock* (grey)		2 "
6.	Compact black limestone		1 "
7.	*Cement rock* (grey), four strata		12 "
8.	Black coralline limestone (various radiaria, cyathophillia, catenipora, etc.)		8 "
9.	*Cement rock* (grey to black)		8 "
10.	Limestone, dark colored, impure and fossiliferous		8 "
	Thickness of the limestones and cements		203 feet.
11.	Hudson slates and grits, thickness unknown (*a*).		

At the extreme southwest end of the hill, the strata are much deranged and bent; but a little farther east, at the quarries, and along the face of the cliff, they are finely exposed, dipping at a moderate angle to the east-southeast.

The limestones of the Helderberg division overlie the slates of the Champlain division unconformably, at Becraft's mountain, near the Hudson. The unconformability, faults, and overturning of some strata are represented on Plate 24, figs. 4, 5, 6; and of Mount Bob, Pl. 38, fig. 31.

There is an anticlinal axis along the broken ridge between the Esopus creek and the Rondout. The rocks on the northwest of this axis dip to the west-northwest at a small angle, conformable to the general dip of the rocks which overlie them on the northwest side of the valley, and which do not appear to have been much disturbed by the upheaving action that has dislocated and upturned all the rocks east and south of this valley. On the southeast of this axis, the strata are broken and upheaved, dip to the south-southeast at angles from twenty to eighty degrees, and present successive mural escarpments (Vide Pl. 8, fig. 9). There are several anticlinal lines, and lines of fault parallel and subordinate to the main axis. One of them passes through two small lakes in Marbletown (Vide Pl. 8, fig. 10; and Pl. 26, figs. 2,

* Mr. Hasbrouck has three quarries leased out on Pine mountain, between Rondout and Kingston point. One of them, six hundred and fifty feet in length, is leased for two hundred and fifty dollars per annum, and yields about forty tons of cement rock per diem, which is sent to Newark, New-Jersey, to be burned.

3). A high mural precipice, originating in a fault, passes along the east shore, while two long promontories with arched strata stretch far into the lake from its extremities (Vide Pl. 26, fig. 2). The same continues to the other pond, and the continuation of this fault and anticlinal axis is easily traced thence by the eye over the whole line of hills, to the summit of the Shawangunk mountain, ranging south fifteen to twenty degrees west. This line of fault continues south-southwest by Flint's quarries, between which and Bridgeport it forms the high mural scarp of mountain on its west side; thence across the country from Bridgeport, with mural escarpments, to a high cliff on the Shawangunk (Vide Pl. 7, fig. 1).

Other lines of fault are seen at Lawrenceville, and which may be traced to cliffs on the Shawangunk. Near Lawrenceville, the limestone beds may be seen downheaved, and abutting against the Shawangunk grit (which underlies) by successive faults (Vide Pl. 7, fig. 4).

A disruption, or double line of fault, with an included anticlinal axis, may be seen between the upper end of Lawrenceville and the bridge across the Rondout, on the road to Highfalls (Vide Pl. 26, figs. 4, 5, 6). It extends south twenty degrees west, to the gap on the Shawangunk mountain, where the same appearance presents itself, and which can be seen on the opposite side of the mountain from many parts of Orange county (Vide Pl. 26, fig. 6).

Various sections and diagrams will illustrate these and numerous similar facts in Plate 26, in fig. 8 of Pl. 27, and on Pl. 8.

The limestones of the Helderberg division, in the Mamakating valley, from Carpenter's point on the Delaware, to Kingston, are all upturned, and frequently at a pretty high angle. In the township of Deerpark, Orange county, they "form a narrow range of hills or low mountains," sometimes sinking almost to the level of the Neversink valley, and at others rising to one-third or half the elevation of the Shawangunk. They are always narrow, and generally close to the base of the last named mountain. The rising and subsiding of the tops of this ridge afford one of the most prominent features of this part of the valley, and add greatly to its picturesque beauty."* These limestones dip in a west-northwest direction, lying upon the subjacent Shawangunk rocks conformably; but some of the strata are rather enigmatical, and appear to dip to the east-southeast in consequence of the cleavage or shivering of the strata since their deposition. In some of the strata, the *real* dip is evident, but in others it is not,† and it was only after minute examination that the real direction was with certainty determined.

In Sullivan county, the Helderberg limestone rarely shows itself above the level of the quaternary deposits of the Mamakating valley, to which it is confined; but where it is visible, it dips to the west-northwest, at a high angle. From Redbridge, on the canal, on the line between Sullivan and Ulster counties, these rocks show themselves more frequently, emerging from the quaternary deposits of the valley, from the place mentioned down the valley by Ellenville, Napernock and Wawarsing (Vide Pl. 15, at Ellenville; Pl. 6, fig. 7, at Redbridge; Pl. 39, figs. 1, 2, at Redbridge.

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* Dr. Horton's Report on the Geology of Orange county, N. Y. Geol. Rep. of 1839, pp. 150, 151.

† Vide (*d*) Pl. 39, fig. 3, *c*, *d*, *e*, in this section form the Helderberg division.

That near Redbridge, dips at an angle of fifty to seventy degrees to the west-northwest, and is traversed by veins of calcspar. The direction of the veins is S. 60° E. The limestone belongs to the Water-lime series, though some of it makes good lime. This is the case with many of the strata in the Water limestone series, in almost all the localities where the strata are exposed. Two miles farther down the valley to the north-northeast, the rock appears again on the land of Mr. Wurts. The upper beds of the Water limestone series here emerge from the quaternary deposits, on the east side of the Sandberg creek. Some of them would make fine marbles, and the rock has been burnt for lime. Like that at Redbridge, the rock is traversed by veins of calcspar, the direction of which is S. 60° E.

Near Napernock, the same strata are visible in the meadows opposite to where the Esopus creek enters the Mamakating valley and unites with the Sandberg creek.

Near Wawarsing, on the west side of the valley, the same strata were seen ; and in all these cases, they dip rapidly to the west, and plunge below the rocks of the Erie division.

In the vicinity of Rochester, Ulster county, the limestones of the Water-lime group are visible in many places, and here the Pentamerus limestone is seen in some localities above the Water-lime group, and characterized by its peculiar fossils.

Fossils were rarely seen in the limestones of the Helderberg division south of Rochester, except in those of the mountain east of Carpenter's point, between that place and the Shawangunk mountain, and at this place they were extremely abundant. The specimens of trilobites were so numerous, and particularly the Asaphus, that Dr. Horton and myself gave the hill the name of *Trilobite mountain.*

Fossils abound in the limestone strata overlying the Water-lime group south of Rochester, between the Stony kill and the Rondout kill. On Mr. Schoonmaker's land between those streams, the water limestone is well exposed. Some of the strata will make marbles and fine building stone. Lime and cement could also be made in this vicinity from the beds of the Helderberg division.

The lines of disturbance and upheave in this vicinity correspond with the general directions recognized in the First district of New-York. The main line here is N. 20° E. and S. 20° W., and the dip is N. 20° W. about 10°.

It will be observed here *that the direction of the dip is not perpendicular to the direction of the main axis of elevation.* This is a very common fact, and observed in a great number of localities in the regions of the First district of New-York, where the strata have been broken up since their original formation.

The strata are traversed by two great systems of fracture, one longitudinal, and approaching more or less to the direction of the strike ; the other transverse. Their usual directions are S. 20° W. and N. 20° E. for the first, and S. 60° E. and N. 60° W. for the second.

When the elevatory movement has been along the *transverse* fractures, the dip is sometimes to the north-northeast, but most frequently to the south-southwest; and when the upheave has been along the *longitudinal* fractures, the dip is to the west-northwest or to the east-southeast. The upheaves have generally occurred along both these lines of fracture, giving echelon movements to the masses of strata, so that their dip is commonly oblique to the direction of

ranges of hills and mountains, and even to the usual line of the emergence of the strata on the surface. The southeast angles of the masses, between the intersecting fractures, are usually elevated, giving mural precipices on the eastern and southern faces of the hills, while the strata dip more or less gradually to the northwest.

The fact of two great systems of fracture in our rocks, which approach to regularity of direction within comparatively narrow limits, and that the *southerly* ends of masses of strata are almost constantly elevated along the traverse lines of fault, while the proper axes of elevation follow the other or longitudinal lines of fracture, has already been adverted to. The *results* of these *combined* elevations, are echelon movements of the strata. The successive ridges sink gradually to the northeast, until they disappear, while they are frequently succeeded by other ridges, which are not in the exact lines of prolongation of the former, but obliquely lateral to them. These in turn sink, and so on. If the faults are numerous, a serrated or broken outline is given to the ridges.

The same general principles hold true, and much more strongly marked in character, in the rocks lying lower in the series, as the Hudson slate group, the Shawangunk grits, and the rocks of the Highlands, except that the *southwest angles* of most of the masses of these latter strata have been highly elevated, giving a high *easterly* dip, and that they have been exposed to a *greater number* of elevatory movements, producing a greater derangement of the stratification.

Most of the streams follow the lines of these two systems of fracture, changing from one to the other to produce many of their changes of direction. I have been enabled to trace some of these lines of fault across mountains and valleys, for many miles.

Metallic veins occur in several places along both these systems of fracture; and it is mostly in consequence of the echelon movements that have occurred in the strata since their first breaking up,* that it is a matter of so much practical difficulty to trace out the continuation of metalliferous veins and beds, so as to open them in the most favorable locations.

Some of the disturbances of the strata about Kingston have already been described.

The limestone of the Helderberg division emerges from the sandy plains around Kingston, about one mile to the east. The strata dip variously in different localities. This ridge is within the line of disturbance that crosses the Shawangunk mountains, and extends northward by Catskill, Athens, Coxsackie, New-Baltimore, Cohoes falls, Baker's falls, and still farther north.

On the road from Kingston to Wilbur, about half a mile from Kingston, the limestone containing hornstone, was observed dipping slightly to the west. It is overlaid by the grey limestone. One-fourth mile farther south-southeast, towards Wilbur, the black slaty, scaly limestone (perhaps the cauda galli grit altered by causes that have upturned the strata) appears in nearly vertical laminæ, but the strata seams are not highly inclined. Some of the characters

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* There are distinct evidences of at least three elevatory movements, viz. one (at least) before the deposition of the Shawangunk grit strata; another after the deposition of the Shawangunk, Helderberg and Catskill mountain series, and before the tertiary epoch; and another at least since that period.

of this rock in stratification and cleavage in other localities, are illustrated on Pl. 8. figs. 8, 9. The remainder of the distance to Wilbur, and thence to Rondout, the strata are very much broken up and contorted, having been tranversed by numerous faults and wrinklings, so that they are bent and dip at all angles to the horizon.

Nearly all the strata of the Helderberg division may be seen in numerous places within a few miles of Kingston; but they are so broken up, deranged, and even *overturned*, that if there were not other localities where the undisturbed strata could be examined, the superposition of the whole of the different members could be definitely settled only after long and careful examination, and collating numerous observations. It is perhaps unnecessary to specify places, where every hill, cliff, and ravine, present interesting localities. The vicinity of Kingston presents many facts of high geological interest, and will be often visited by those who are interested in geological investigations.

In some places fossil remains abound, but generally around Kingston they are rather rare. Most of the strata of limestone exposed, belong to the Water-lime series. Fossil remains abound in the limestone and decomposing siliceous limestone at the Falls of the Esopus, opposite Mr. Clark's house, and below the white lead factory. The position of the rocks at this place is illustrated on Pl. 8, fig. 6. They dip about 30°, N. 70° W. The stream flows along the line of fault from the lead factory, northwards about three-quarters to one mile. Throughout this distance, fossils are extremely abundant, and some strata are almost exclusively composed of them. The right bank of the Esopus from the Falls to near Glasco, affords a rich treat to all who are fond of seeing these medals of ancient times. The fossils are several species of delthyris, strophomena, atrypa, gorgonia, cyathophyllum, asaphus and encrinite, and many others, similar to those of the Helderberg and Becraft's mountains.

Another locality where fossils abound, is about a mile from Bridgeport, about north, or a little east of north of that place. The strata dip about forty degrees to the east-southeast.

The strata of the Helderberg division continue as broken, upheaved and wrinkled masses, from Kingston as far north as the south line of Albany county.

Between Kingston and Saugerties, about a mile south of the limekiln, the road leads along an apparent disruption of the strata, and in some places these strata dip in opposite directions from the narrow valley through which the road passes (Vide Pl. 7, fig. 9). The strata of slate of the Hudson group were seen emerging in many places along this line of disruption, and in others, the black slaty crumbling limestone which is associated with the cement rock. This slaty calcareous rock might easily be mistaken for the slates of the Hudson group.

The undulations and wrinkles of the rocks of the Helderberg division, between Catskill and the Mountain House, are illustrated on Pl. 38, fig. 14.

On this section S indicates the Hudson slates.

L	"	Helderberg limestones.
M	"	Marcellus shales.
T	"	Quaternary clay and ore beds.

This section is a continuation of the detailed section given on pages 303 to 305 of this volume, including the Catskill and Erie divisions, from the summit of the Catskill mountain to the stone bridge across the Kaaterskill, where the Marcellus shale is seen overlying the Helderberg limestone.

Some curious contortions may be seen between the line of this section and where the Helderberg limestones cross the Catskill creek. Below Madison, on the road to Catskill, the creek is seen flowing along the line of bearing of the strata for about one quarter of a mile. One of the strata here shows a real *warped surface*, such as is defined in mathematics. The stratum dips down under the creek, at a high angle, at one end of the place referred to, and at the other, a distance of perhaps two or three hundred yards, it dips down at a very moderate angle; and at intermediate points, the dip varies very regularly between these extremes. It is thought probable that an extension of this warped stratum, if traced out, would show the strata reversed in dip and superposition, like some of those on Pine mountain and near High rocks in the vicinity of Kingston.

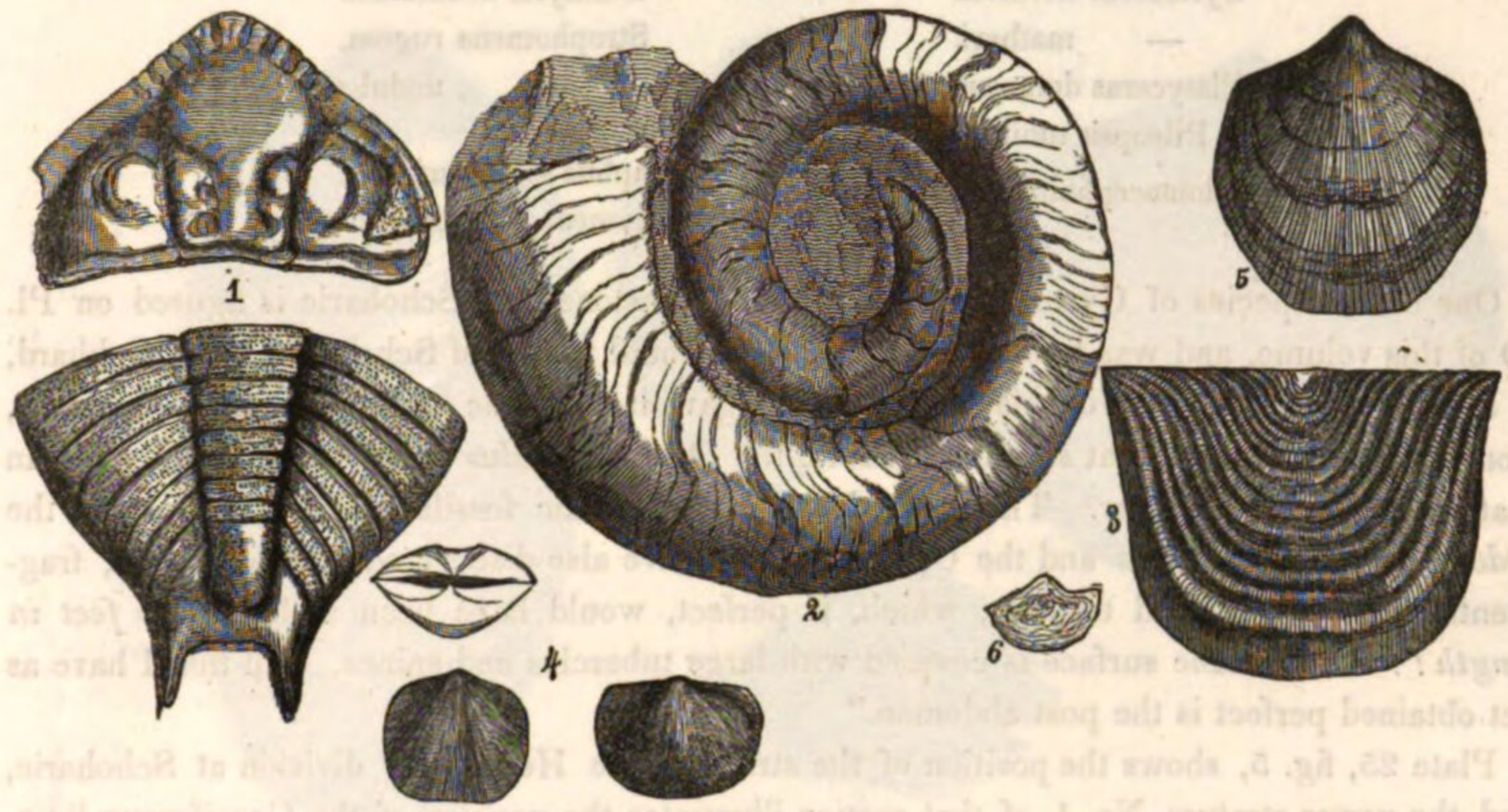
The Delthyris shaly limestones, the Pentamerus limestone and the Water limestones, are the most common rocks, and in fact form almost the whole mass of the Helderberg division through the region in which we have traced the derangements from Carpenter's point on the Delaware, to the south line of Albany county. They also form the most prominent masses in the Helderberg mountains. They are found successively in passing from the Hudson westward in Ulster and Greene counties, and are well characterized by their fossils. They generally present cliffs and mural escarpments to the east, as may almost every where be seen in their range from Kingston to the Helderberg, in consequence of their dip to the westward. Limestone springs, caves and subterranean streams, which are not uncommon in the Helderberg rocks, have already been described. (Vide pp. 109, 112.)

Agricultural character.

The limestone and slate lands of the Helderberg group are rolling, with a good soil, and very productive for wheat and other crops. The strata are generally nearly horizontal; but through the valley of the Delaware and Hudson canal, and from Kingston to Coxsackie, the rocks are upheaved, and sometimes overturned. Many parts of this region are very rough and broken.

1. Corniferous Limestone.

Fig. 16.



1. Odontocephalus selenurus.
2. Cyrtoceras undulatus.
3. Strophomena undulata.
4. Orthis lenticularis.
5. Atrypa prisca.
6. Strophomena lineata.

This rock is the uppermost member of the Helderberg division. The above name was given to a limestone containing hornstone, by the late Prof. Amos Eaton, and is retained as appropriate to this limestone, though hornstone and chert are not peculiar to this rock. These minerals are also found to be common in the other calcareous members of the Helderberg division. The Corniferous limestone is characterized by its fossils, which are numerous. The coiled shells called the Cyrtoceras, of which there are several species, are perhaps those that may be considered as characterizing this limestone. The woodcut above, prepared by Prof. Vanuxem to illustrate some of the characteristic fossils of the Third district, will answer equally well for the First district. The strata are the same, slightly varied in mineralogical composition, and contain the same fossil remains. The Corniferous limestone is used in Schoharie for burning lime, and is considered as making the whitest and strongest lime. Specimens of the Cyrtoceras are very frequently found in breaking the stone at the limekilns.

The rock is coarsely subcrystalline grey limestone, containing courses of nodules of hornstone. In some places the rock is darker colored and more impure.

The Corniferous limestone is found from near Leesville, in the west part of Schoharie county, ranging eastward by Cobleskill and Schoharie, to the top of the Helderberg, thence southeast and south to Esopus falls; and patches of it are seen occasionally among the upheaved masses about Kingston, Hurley, Bridgeport, Rochester, &c. The fossils will be

described in the Palæontological Report. The following have been described by Mr. Conrad, in the Annual Reports, viz.

Cyrtoceras trivalvis.
— matheri.
Platyceras dumosum, or
Pileopsis tubifer.
Odontocephalus selenurus; same as { Asaphus selenurus, and Calymene odontocephalus.*
Delthyris acuminata.
Strophomena rugosa.
— undulosa.

One of the species of Cyrtoceras found in this limestone near Schoharie is figured on Pl. 19 of this volume, and was figured by Mr. J. G. Gebhard junior, of Schoharie. Mr. Gebhard, in a letter to me, speaking of this rock, says, "I gave it the name of the *Selenurus limestone*, from the occurrence of that singular trilobite the *Odontocephalus selenurus*, which occurs in that rock, but in no other. The marked and characteristic fossils of this stratum are the *Odontocephalus selenurus* and the *Cyrtoceras*. I have also discovered in this stratum, fragments of an undescribed trilobite, which, if perfect, would have been at least *two feet in length!!* The whole surface is covered with large tubercles and spines. All that I have as yet obtained perfect is the post abdomen."

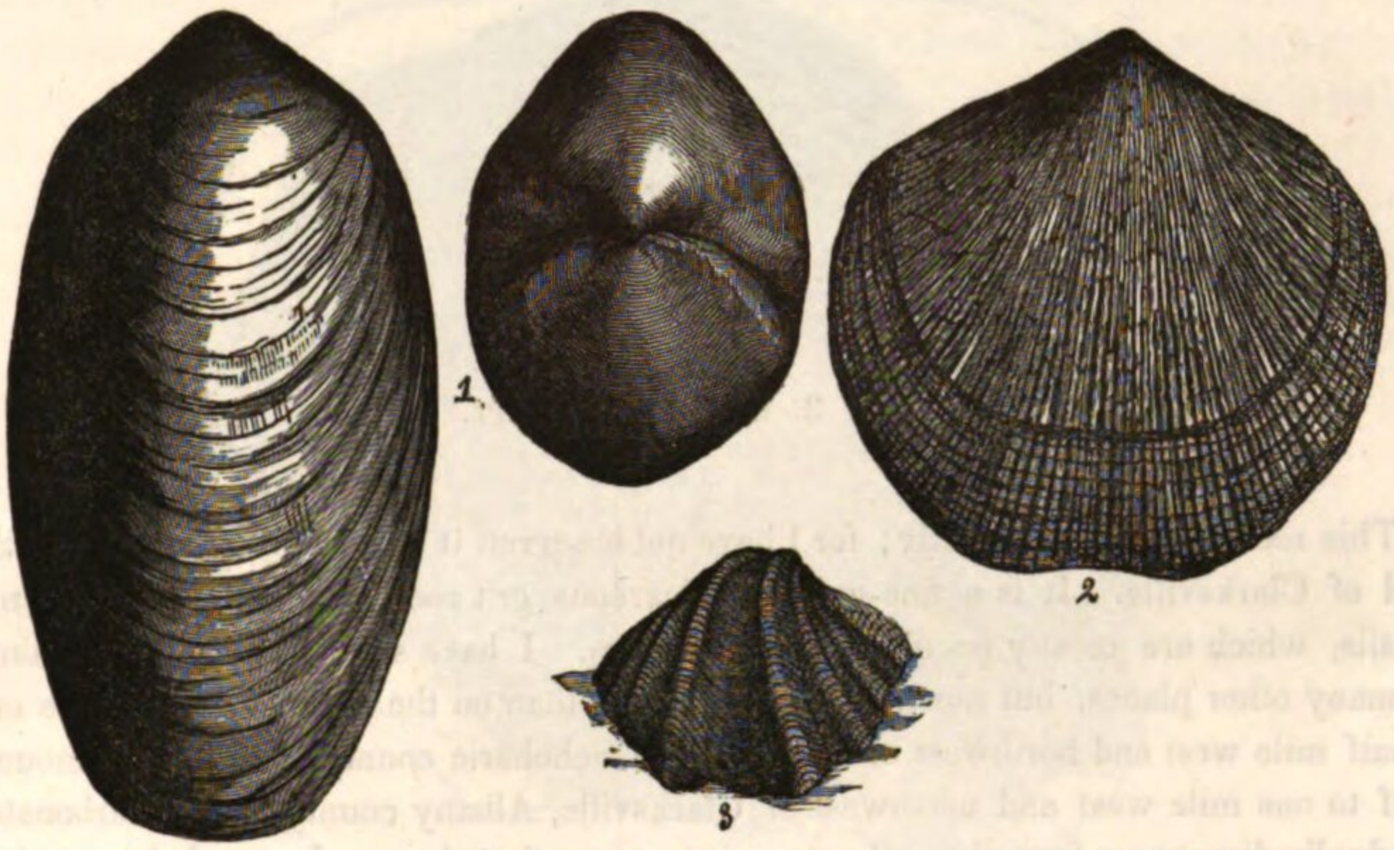
Plate 25, fig. 5, shows the position of the strata of the Helderberg division at Schoharie, and the upper stratum No. 1 of that section illustrates the position of the Corniferous limestone at that place.

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* The different parts of this trilobite were supposed to belong to different species, and received different names, until an entire specimen was found (Vide Prof. Vanuxem's Report, p. 140).

2. Onondaga Limestone.

Fig. 17.

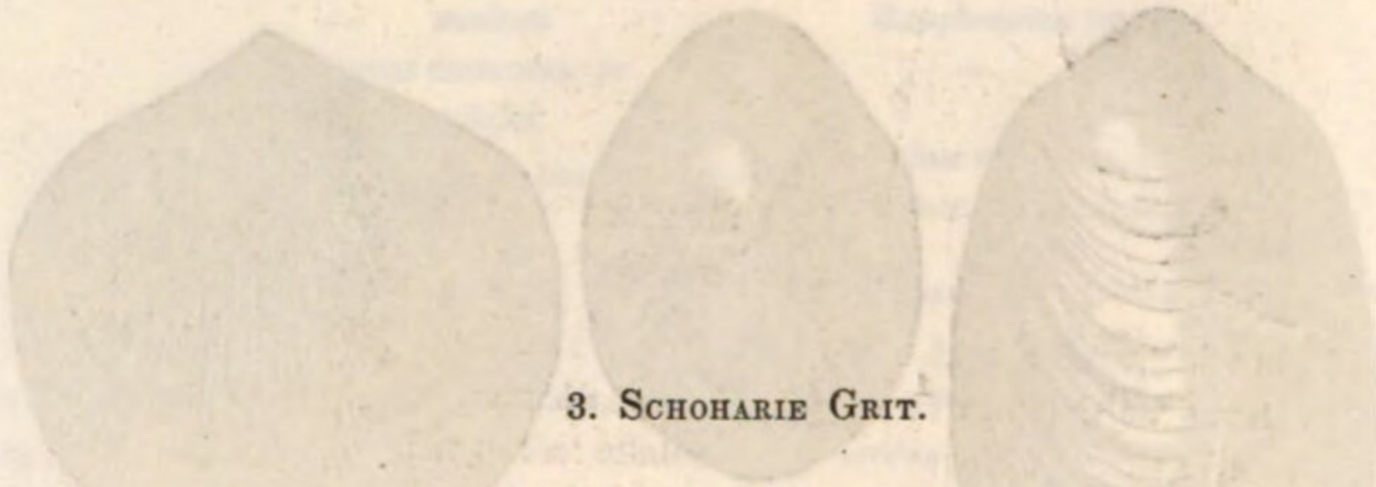


1. Pentamerus elongata. 2. Hipparionix consimilaris. 3. Delthyris undulatus.

This rock, the upper member but one of the Helderberg division, is remarkably uniform in character, and is more extensive even than the preceding, or Corniferous limestone. It is generally a coarse-grained subcrystalline grey limestone, and contains great numbers of the Cyathophyllum, some of which are very large. The Favosites is also very common, and I have seen more beautiful specimens of this fossil on the Helderberg mountains in Sharon, Bern and Bethlehem, than from any other part of the world. Hornstone occurs in nodules and interrupted layers in some localities of this rock. The fossils are numerous, and will be described in the Palæontological Report. The following have already been described by Mr. Conrad, viz :*

Delthyris raricosta.
Strophomena gibbosa.
— perplana.
Atrypa nasuta.
— unisulcata.
— acutiplicata.
Avicula pecteniformis.
Cypricardites inflata.
Bellerophon curvilineatus.
Pleurotomaria poulsoni.
— unisulcata.
Asaphus aspectans.

* Vide Prof. Vanuxem's Report, p. 138, and remarks on synonims.

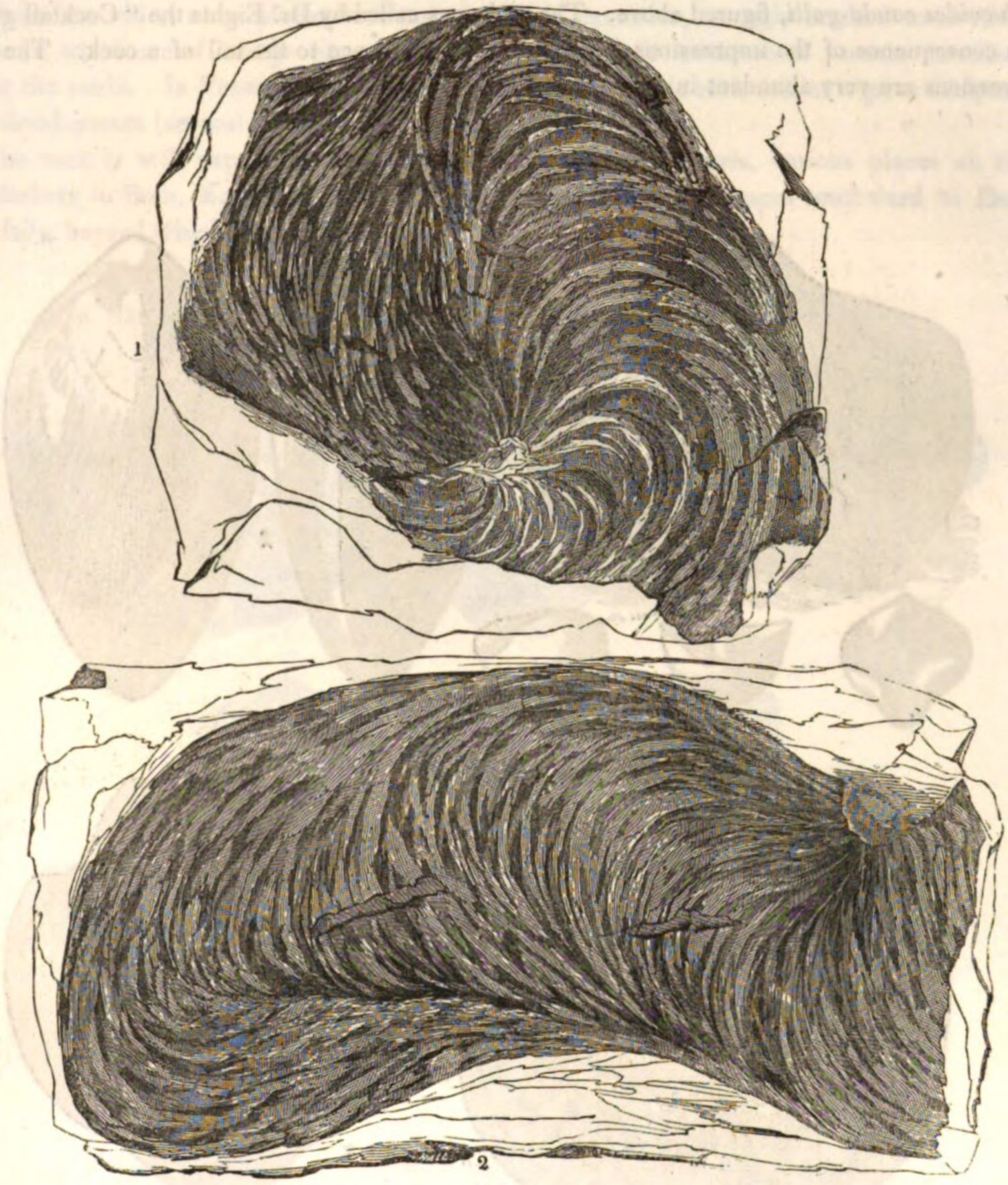


3. Schoharie Grit.

This rock is local, apparently; for I have not observed it except in the vicinity of Schoharie and of Clarksville. It is a fine-grained calcareous grit rock, containing a great number of fossils, which are mostly peculiar to that stratum. I have seen fragments of a similar rock in many other places, but nowhere else in place, than on the mountain about one or one and a half mile west and northwest of Schoharie in Schoharie county; and on the mountain one-half to one mile west and northwest of Clarksville, Albany county. The carbonate of lime gradually disappears from the rock where it is exposed to the weather, and the remaining mass is a rather porous and spongy fine-grained tough sandstone. Orthoceratites and the Pleurorhynchus are abundant, and are perhaps as characteristic fossils as any. I sent specimens of the fossils of this rock to Prof. Bronn of Heidelberg in 1833 and 1834. They are probably figured and described in his *Lethæa Geognostica*, but I have not a copy of the work for reference, to know certainly whether they are described. The fossils of this rock will be figured and described in the Palæontological Report.

4. Cauda-galli Grit.

Fig. 18.

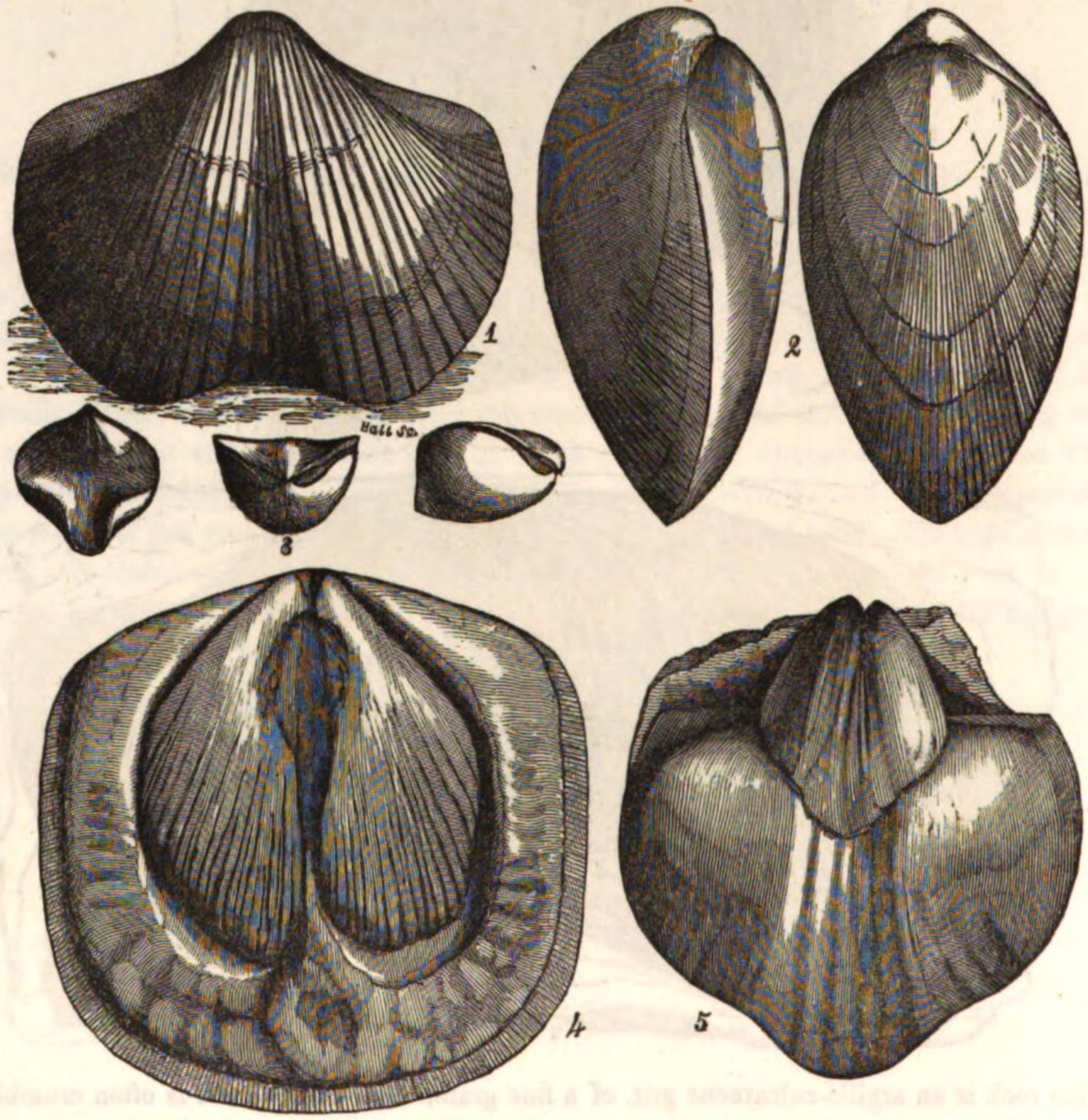


This rock is an argillo-calcareous grit, of a fine grain, almost slate, and is often crumbling into small fragments when exposed to the weather. In some places it is almost black, more frequently grey or buff-colored; and when weathered, grey and light buff. It has a thickness of fifty or sixty feet in many places in the First district, being a much thicker rock than the overlying members of the Helderberg division. It extends from the west line of Schoharie

county, eastwards by Schoharie to the eastern brow of the Helderberg mountains; thence southeast and south to Kingston. It has not been recognized in the Mamakating valley farther to the southwest than Marbletown. This rock is characterized by the impressions of the *Fucoides cauda-galli*, figured above. The rock was called by Dr. Eights the "Cocktail grit," in consequence of the impressions having some resemblance to the tail of a cock. The impressions are very abundant in many localities.

5. Oriskany Sandstone.

Fig. 19.



1. Delthyris arenaria.
2. Atrypa elongata.
3. Atrypa peculiaris.
5. Internal cast of Hipparionix proximus.
5. Internal cast of Delthyris arenaria.

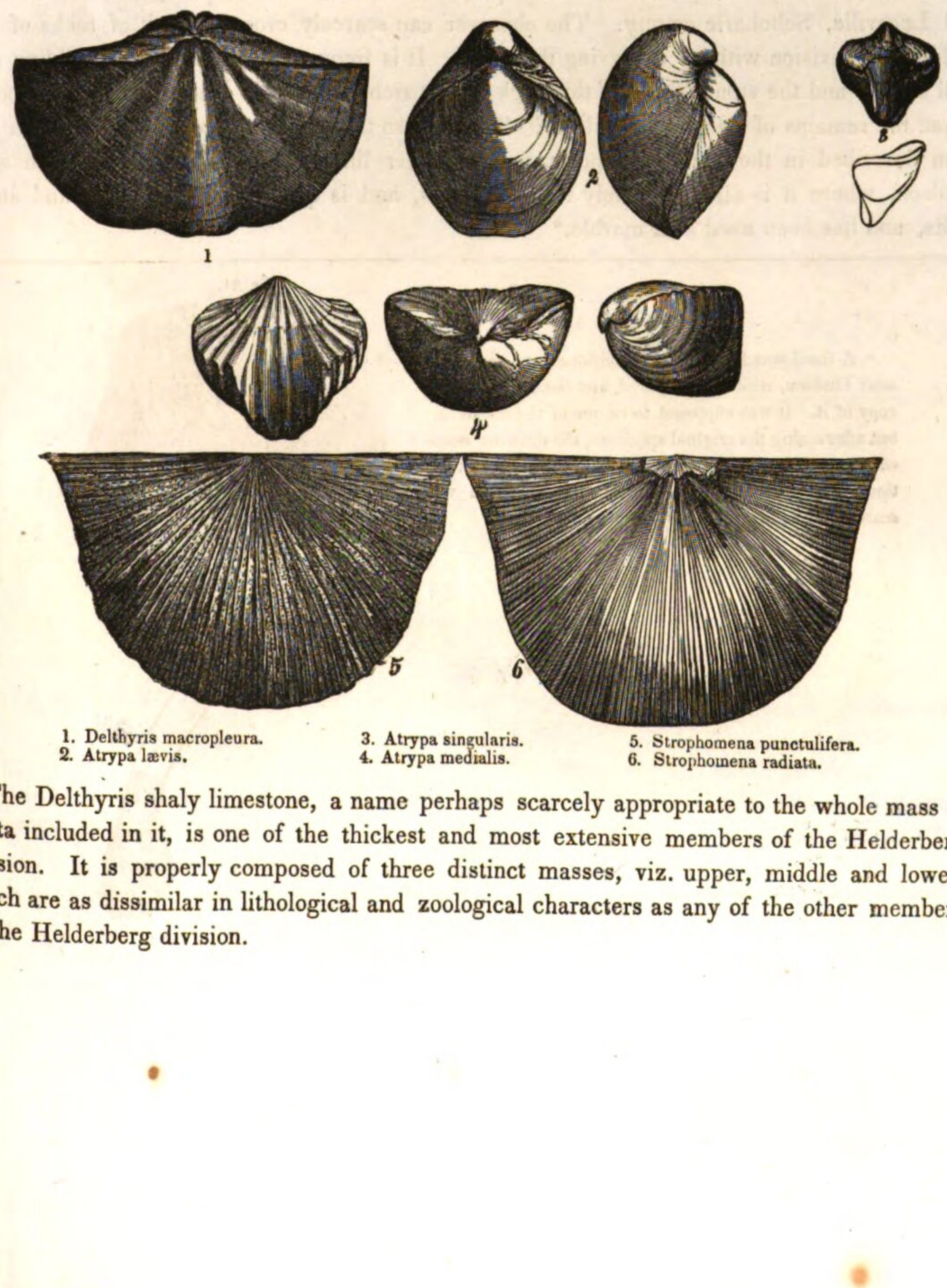
The Oriskany sandstone is generally a hard siliceous grit, which generally approaches chert and hornstone in aspect, and is replete with fossils. In some places it is white; in others

brown, red and black; and it is sometimes slightly calcareous. The fossils are crystalline carbonate of lime; but on the surface of the earth, the moulds of the fossils only remain. In the First district, it rarely exceeds two feet in thickness, and in many places is not more than eight inches, and in some places is absent; but it is extensive, strongly marked in its fossil contents, which are of a large size, and generally attracts the attention of persons travelling along the roads. In Pennsylvania, Maryland and Virginia, this rock attains a great thickness and development (several hundred feet).

The rock is well exposed in the hills east and west of Schoharie, various places on the Helderberg in Bern, Knox and Bethlehem, and occasionally as it ranges southward to Esopus falls, beyond which it was not recognized.

6. Delthyris Shaly Limestone, or Catskill Shaly Limestone.

Fig. 20.



1. Delthyris macropleura.
2. Atrypa lævis.
3. Atrypa singularis.
4. Atrypa medialis.
5. Strophomena punctulifera.
6. Strophomena radiata.

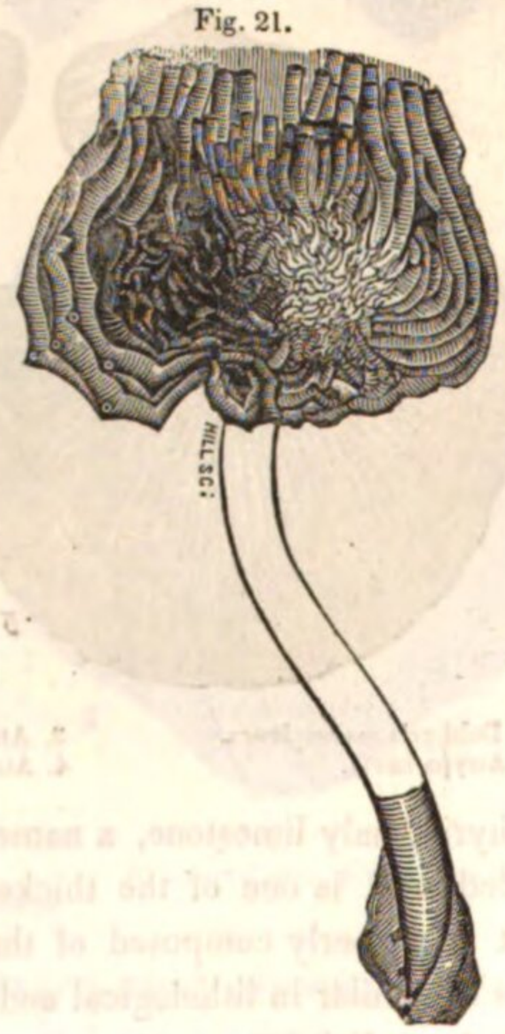
The Delthyris shaly limestone, a name perhaps scarcely appropriate to the whole mass of strata included in it, is one of the thickest and most extensive members of the Helderberg division. It is properly composed of three distinct masses, viz. upper, middle and lower, which are as dissimilar in lithological and zoological characters as any of the other members of the Helderberg division.

(*a*). The *upper subdivision* is the same that has been called by Mr. Vanuxem, in the Annual Reports, the "Scutella limestone," and by Mr. Gebhard the "Sparry limestone." The rock is a coarsely subcrystalline grey limestone, replete with fossil remains. Encrinal, coralline and testaceous remains are extremely abundant, and each stratum has some that are peculiar to it. The shallow, almost discoidal pelvis of an encrinite, (the resemblance of which in general form to the *scutella* gave the name to the rock,) is very abundant, and serves to define and limit this stratum, as a convenient one for reference. Favosites abound in some parts of this rock. A branched encrinite is also very common and characteristic. This rock is well developed from the west line of Schoharie county, ranging eastward by Schoharie to the east brow of the Helderberg, and thence southeast by Clarksville, to within two or three miles of the Hudson; thence south near Madison to Kingston. It may be seen well characterized on the road from Catskill to the Mountain House; also not far from Madison, Greene county; also on the turnpike from Albany to Rensselaerville, about half to three-quarters of a mile east of Clarksville, Albany county; and in many places on the western turnpike, between Carlisle and Leesville, Schoharie county. The observer can scarcely cross the belt of rocks of the Helderberg division without observing this rock. It is frequently quarried as a building and wall stone; and the stone fences of this rock offer a rich treat to one who examines the rocks, to see the remains of ancient animal life. This is also the same limestone as that which has been described in the Annual Reports, as the upper limestone of Becraft's mountain near Hudson, where it is also extremely rich in fossils, and is quarried for buildings and stone walls, and has been used as a marble.*

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* A fossil was found in this limestone some years ago, near Hudson, which was figured, and the subjoined is a copy of it. It was supposed to be one of the crinoidea; but after seeing the original specimen, the drawing seemed more distinct than the specimen, and some restorations had been made that the original specimen will scarcely warrant.

Fig. 21.



(*b*). The *middle subdivision* is a slaty limestone, containing a great number of individuals of many genera and species of testacea, corallines and encrini, and some trilobean crustaceæ. Some species of the Pentamerus are characteristic. This rock is quarried in many places for stone walls, for which it is well adapted, splitting out in layers from an inch to half a foot thick; and the stone fences of this rock show a multitude of fossils and of great variety, washed clean by the rain, and ready for the collector to have the best opportunity for selection. This rock is coëxtensive with the former, and may be seen along its outcrop in very many places in Schoharie, Albany, Greene and Ulster counties, and at Becraft's mountain near Hudson, Columbia county. The best localities I have seen are one and a half miles north of Clarksville, and one mile west of Salem, in Albany county, and on the hills east and west of Schoharie.

(*c*). The *lower subdivision* is a mass of slaty argillo-siliceous limestone, abounding as much in fossil remains as the two preceding. The *Strophomena rugosa*, *S. radiata* and *S. punctilifera*, are perhaps the most abundant fossils. The lithological characters of this rock are very different from any of the others in the series, and can scarcely be mistaken if once recognized. It was not seen at Schoharie, or west of that place; but east, on the Helderberg, and thence southeast and south to Kingston, it is a prominent, well characterized rock. It is the same as the middle limestone of Becraft's mountain near Hudson. It may be seen near Esopus falls; west of Catskill; near Madison; west of Saugerties; west of New-Baltimore; one mile north and northwest of Clarksville, &c.

Some of the strata of the Catskill shaly limestones afford as beautiful cabinet specimens as I have ever seen; even the most minute corallines, of which there are many species, when examined by a lens, show their minute pores and markings.

The Delthyris or Catskill shaly limestone probably contains more fossils, both in genera, species and individuals, than any other rock of equal thickness in the State.

The following fossils found in this limestone, have been described by Mr. Conrad in the annual reports, but they form only a small part of its contents.

Crustacea.

Ascidopsis tuberculatus.
Acantholoma ———.
Asaphus pleuroptyx.
— nasutus.
Dicranurus ———.

Corallines.

Calamopora favosa.

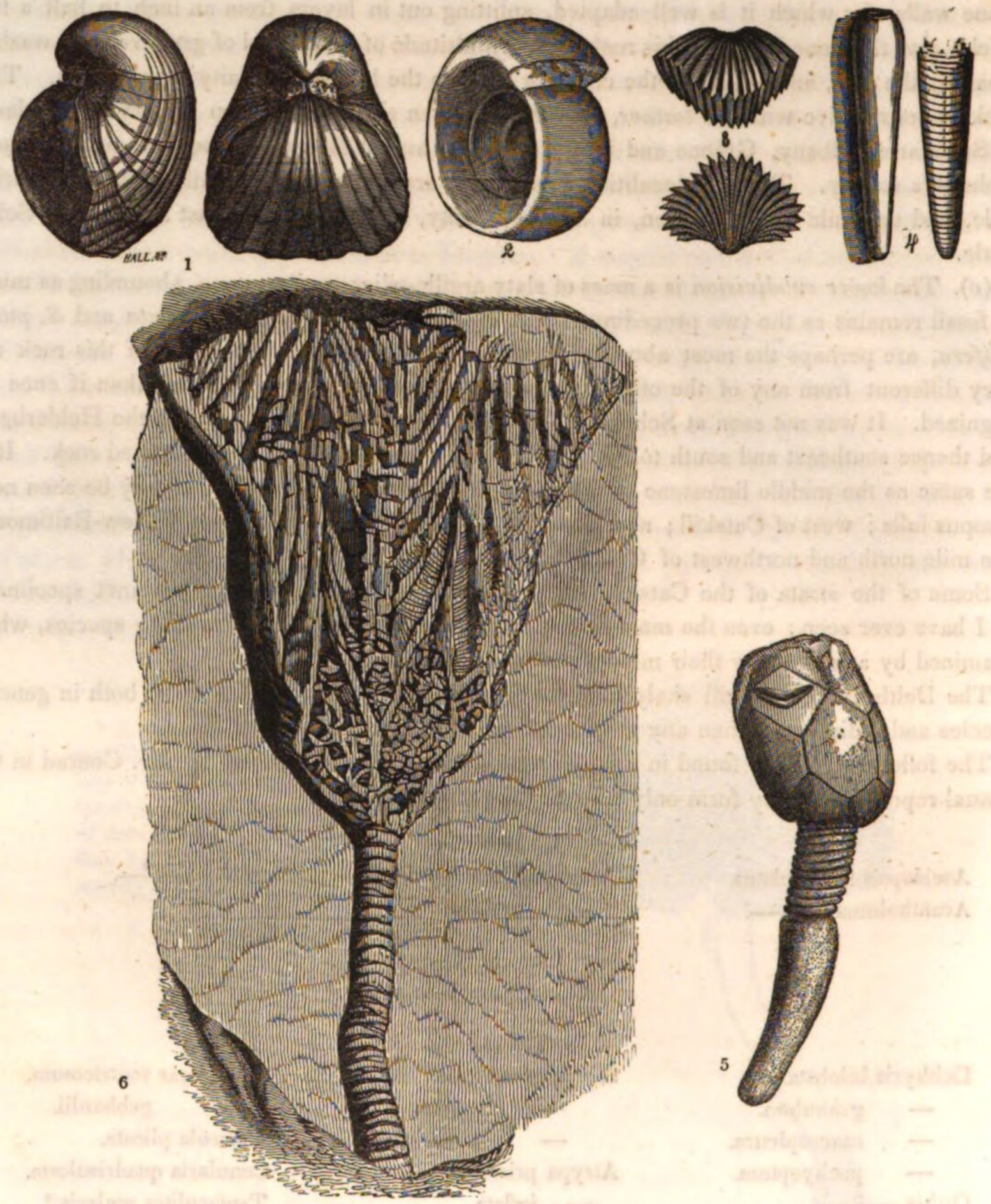
Testacea.

Delthyris bilobata.
— granulosa.
— macropleura.
— pachyoptera.
Orthis ———.
Strophomena rugosa (depressa).
Strophomena punctulifera.
— radiata.
— indentata.
Atrypa prisca.
— inflata.
— concentrica.
Platyceras ventricosum.
— gebhardii.
Calceola plicata.
Conularia quadrisulcata.
Tentaculites scalaris.*

* Vide Prof. Vanuxem's Report, p. 122.

7. Pentamerus Limestone.

Fig. 22.



1. Pentamerus galeatus.
2. Euomphalus profundus.
3. Atrypa lacunosa.
4. Lepocrinites gebhardii (base of the column).
5. — —
6. Astrocrinites pachydactylus.

The Pentamerus limestone is a mass of rock some fifty feet in thickness, divided into various strata and slaty layers, by strata seams, and thin partings of a fine argillaceous slate or shale. It contains many genera and species of fossils, and multitudes of individuals of many of them. The rock is a slaty and subcrystalline grey and black limestone, containing in some places in its upper layers courses and flat nodules of hornstone. It is a very extensive and well developed rock in the First geological district, in which it forms a continuous stratum from the west line of Schoharie county eastward to the Helderberg mountains in Bern and Bethlehem, whence it extends southeast and south to Kingston, and thence southwest by Hurley to Rochester; it then disappears beneath the quaternary of the Mamakating valley, and is rarely seen from that place to Carpenter's point on the Delaware.

It is well exposed to view near the village of Schoharie, where its fossils have been carefully examined by John G. Gebhard junior, esquire, and others, for many years. This gentleman has made a more perfect collection of the fossils of this, and of other members of the Helderberg division of rocks, than any other person.

It is well exposed also half a mile south of Sharon springs in Schoharie county; near the Great falls of the Esopus, and in Rochester in Ulster county; and in a great number of intermediate places, too numerous to mention. In all the places mentioned, and in a great number of others, the base of the *Lepocrinites gebhardi* is found in abundance in a particular stratum, associated with some species of Atrypa and Pentamerus, and the vertebræ of another species of encrinite. Plates of the pelvis of the *L. gebhardi* are also not uncommon. The base of the *L. gebhardi* was first noticed, I believe, by the Messrs. Gebhard, Dr. Foster and myself, in 1830; and we called it the *Mulberry encrinite*, in consequence of a general resemblance in form to that of the fruit of the mulberry.

The above fossil (fig. 5), is characteristic of the middle part of the Pentamerus limestone, and has as yet been found in no other position in the First geological district; while the *Astrocrinites pachydactylus* (fig. 6) is equally limited in geological position to the base of this limestone, next the upper layers of the Water-limestone group.

The latter fossil was first found, I believe, by Mr. John S. Bonny, about the year 1829; and I procured of him, in 1830, specimens more nearly perfect than any that have since been procured, with the exception of the specimen represented in fig. 6. This was obtained by Mr. B. in 1835, and a slight description was published in one of the Schenectady papers, with the above woodcut, under the name of the *Actinocrinites polydactylus*, which has been changed by Mr. Conrad to *Astrocrinites pachydactylus*. The locality where the specimens of this fossil have been obtained most abundantly, is about one-quarter of a mile east of Schoharie court-house, at the base of a limestone cliff, at the junction of the dark colored limestone of the Water-lime group with the grey pentamerus limestone. The fossils are imbedded in a thin stratum of black argillaceous shale, slightly calcareous. The pentamerus limestone overhangs the locality, so that it has been only by great labor that the rock could be exposed sufficiently to procure even a few specimens. The stems, or vertebral columns, are long, and all that I have seen were gracefully curved in arcs of circles or in imperfect spirals.

The section* given by Mr. Bonny, several years ago, shows the position of these fossils. It has been published in one of the Schenectady papers, with the description of the "*Lily Encrinite*," a name by which it was long known, and the same substantially has also been published in the American Journal of Science, Vol. xxvii, 363–4.

At Schoharie (and in fact in almost every locality where the rocks are not upturned by some cause subsequent to their deposition), the Pentamerus limestone and the other members of the Helderberg division form successive terraces of variable breadths, exposing mural fronts in many places, and offering every facility in the cliffs, and in the ravines that extend back from them, for examining the strata and their fossil contents.

The following fossils of the Pentamerus limestone have been examined and described by Mr. Conrad in the annual reports. The remaining fossils will be described in the Palæontological Report.

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* Mr. Bonny has furnished the following description of their locality:

It is situated about one quarter of a mile east of the Schoharie court-house, in a perpendicular ledge of rock about fifty feet high. The different strata occur in the following order:

1*st stratum, about thirty feet.* Shell limerock, containing trilobites of the asaphus variety; the orthocera, spirifer and terebratula of different varieties.

2*d stratum, two feet.* In the centre of this stratum is a layer of clay slate, one inch thick, in which is found the most perfect lily; it also contains the stag-horn encrinite, trilobites and terebratula.

3*d stratum, eight feet.* Stratified limerock containing trilobites, species of the echinus, flustra, and orthocera.

4*th stratum, ten feet.* Stratified limerock, containing species of the echinus and flustra.

5*th stratum, ten feet.* Lias, contains all the strontianite localities discovered by myself; carbonate and sulphate of strontian, barystrontianite of Trail, fibrous sulphate of baryta, water-lime coated with some vegetable remains.

6*th stratum.* Compact limestone containing Columnaria intermedia, marine shells, encrinites and other organic re mains.

7*th stratum.* Siliceous limestone with petrifactions.

8*th stratum.* Greywacke.

Remarks on the Section.

The "terebratula" in the first stratum are a species of the *Pentamerus* (the *P. galeatus*), which is extremely abundant, and in the second is a species of *Atrypa*. The "*clay slate*" is an appropriate term for the shale containing the specimens of *Astrocrinites pachydactylus*, if the idea connected with the *technical* use of that term be discarded.

The third and fourth strata are the Tentaculite limestone, the upper member of the Water-lime group. The tentaculites, from their form and general appearance, were long supposed to be the spines of echini.

The fifth, sixth and seventh strata belong to the Water-lime group.

The names of fossils used in the above section are now mostly changed. The names given are what the fossils were supposed to be by those who found them, and who had few opportunities of ascertaining definitely what they were, either by personal communication with competent palæontologists, (the number of which is extremely small,) or by access to libraries, or even to any of the books that have been published on the subject. Although they knew the objects by sight, and had names by which they designated them, the objects had not been examined with rigor by those who were competent to assign their places in a scientific arrangement. Mr. Conrad, the Palæontologist, has examined and described a part of them.

TESTACEA.

Pentamerus galeatus.
Atrypa lacunosa.
— semiplicata.
Strophomena rectilateris.
— elongata.
Strophomena impressa.
— varistriata.
Avicula naviformis.
— manticula.
Euomphalus profundus.

CRINOIDEA.

Lepocrinites gebhardi.
Astrocrinites pachydactylus.

Two species of Atrypa from the Pentamerus limestone, in form like the *Terebratula wilsoni*, have been named by Prof. Vanuxem; viz. the

Atrypa wilsoni.
Atrypa inflata.*

8. WATER-LIME GROUP.

Hydraulic limestone of EATON. *Part of No.* 6 of Prof. RODGERS' Reports. *Part of Lower limestone of Becraft's mountain, and of Helderberg series of former reports.*

Fig. 23.



1. Orthis plicata.
2. Avicula rugosa.
3. Tentaculites ornatus.
4. Littorina antiqua.
5. Atrypa sulcata.
6. Cytherina alta.

The Water-lime group is composed of hydraulic and common limestone, of various degrees of purity and color, and contains several interesting mineral substances. Fossils, though common, are by no means so abundant as in the preceding calcareous strata. The rocks of this group are coëxtensive with the division, and are frequently seen in the Mamakating valley, where the other rocks of the Helderberg division are not visible, and they are observed to underlie the other rocks of the series throughout the whole of their extent. In Kingston, Hurley, Marbletown, Rochester, Saugerties, Catskill, Athens, Coxsackie, and New-Baltimore, they are remarkably well developed, and can be studied with ease, in consequence of their having been elevated at variable angles, by subterranean disturbances, since their original deposition. These disturbances have already been described, under the head of derangements

* Vide Geological Report of Third District, by Prof. VANUXEM, p. 119.

of the rocks of the Helderberg division. From Coeymans, by Bethlehem, Bern, Schoharie, Cobleskill, Carlisle and Sharon, into the Third district, the rock has a gentle dip to the west and south, cropping out towards the Hudson and Mohawk valleys, with a mural escarpment or a steep acclivity.

The thickness of this group of rock varies from fifty to one hundred and fifty or two hundred feet, in different localities, usually from one hundred to one hundred and fifty feet.

The group is composed of two principal members, viz. the { Tentaculite limestone, and Water limestone ; } each of which might with propriety be subdivided, in consequence of the marked difference of the zoological and lithological characters of the subdivisions.

The *upper* part of the tentaculite limestone is a black and dark grey slaty compact (in some layers subcrystalline) limestone, in layers from an inch to a foot thick, and contains several species of the *Asaphus* and *Calymene*.

The *middle* part of the tentaculite limestone is composed of slaty black layers of compact limestone, containing an abundance of the *Tentaculites ornatus*, *Cytherina alta*, *Orthis plicata*, and some of the *Avicula rugosa*. These are characteristic fossils.

The *lower* part is also composed of black and dark grey compact and subcrystalline limestones, abounding in the remains of radiata, mostly favosites, columnaria, catenipora, etc.

The water limestones with interstratified masses of common limestone, underlie the above. The detailed section opposite Wilbur (Vide page 331 of this Report) shows the alternation and relative thicknesses of the different masses. *Tubipora catenulata*, a coralline like *Catenipora escharoides*, and some other fossils, occur in the locality of that section and some other places, but they are rare.

In some places, one of the beds of the Water-lime group is geodiferous, and contains beautiful crystals of calc spar, and crystalline compounds containing baryta, strontia and lime, minerals that are or will be described in the Mineralogical Report by Prof. Beck. At Schoharie, a stratum of about eight feet in thickness at the base of the Water-lime series of dark colored compact limestone, contains great numbers of globular masses of a species of favosite. Many of these have been polished by Mr. John S. Bonny, and distributed in various parts of the country in exchanges of fossils and mineral specimens. They take a high polish, and the sections through the globular and ovoidal masses exhibit sections across and through the columns in all directions, so as to develop the whole structure of the fossil.

A large conical univalve was found in this stratum of limestone at the base of the Water-lime series, immediately above the green pyritous underlying shales at Schoharie, by Mr. Gebhard, who has made a drawing of it. A single specimen only has been found. Plate 20 of this volume represents this fossil.

Localities out of the general range of the Helderberg division.

"A limestone, containing abundance of fossils, like those of the middle limestone of Becraft's mountain, is found in the town of Cornwall, two and a half miles west of the village

of Canterbury, on the road to Salisbury mills. Its apparent position is between the slate and grit rock, or millstone grit of Prof. Eaton.* Its dip is to the southeast, at a high inclination. Mixed in between the layers of this rock is the hematite, or limonite ore, on the land of Mr. Thomas Townsend. Where the ore exists, the limestone is all more or less decomposed, some parts of the rock and its fossils retaining their form, but have become white or yellow, and soft; other parts, even the nodules of hornstone, are so far changed that they have fallen to fine powder, mixed up with the ore in the same condition. This limestone makes but indifferent lime. The distinctive fossil of this rock is the encrinite, although it contains many others."†

The *Strophomena rugosa* and *S. radiata* are very common fossils at the above locality, and the rock is considered as belonging to the Catskill shaly limestone, which has here been upturned on its edges like the adjoining slates, grits, and other rocks. This locality is the only one where the rocks of the Helderberg division have been recognized southeast of the Helderberg mountains, west of the Hudson river.

Near Hudson in Columbia county, are two outliers of the rocks of the Helderberg division, called Becraft's mountain and Mount Bob.‡ They are composed of limestones, lying uncon-

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* *Shawangunk grit* of the Reports of the First District. † Dr. Horton's Report on the Survey of Orange county, N. Y.

‡ At the foot of Becraft's mountain, the slate dips at a high angle to the east, very near to the junction of the nearly horizontal strata of the Helderberg division, but the actual junction was not seen. At one mile and a half from Hudson, on the south road along the base of Becraft's mountain, the slate is visible on the east side of the road-way, dipping 30 to 40° eastwardly. The strata is S. 30° W., and the dip to S. 60° E. Within two rods of the slate *in place* is a mass of limestone, which at first view would be supposed to be *in place;* but its dip is south 60°, and its strike is east. These circumstances, together with the appearance of the mound in which it is imbedded, give reason to believe it to be a mass *out of place*, that has slidden from the cliff of limestone, that rises with a nearly vertical escarpment sixty or seventy feet above the slope of debris at its foot, within a few rods on the east.

Within a mile farther on the road south from Hudson, many localities almost show the junction of these rocks that seem to be *unconformable;* and at the fork of the roads, the junction can be traced to be within a space of six feet. The slate is here highly inclined, and the limestone nearly horizontal.

The eastern side of Becraft's mountain is also bounded by a mural escarpment, and there the strata dip slightly to the *westward*, while on the west side they dip a little to the *east*. On the north end of the mountain, a cross section is observable, showing the same thing, the strata dipping east and west towards the central axis of the mountain. This accounts for the copious fountain which finds an outlet at the bottom of the inverted arch, which collects the water that drains through the fissures, and forms a reservoir. This overflows at the lowest point, at the spring that supplies the city of Hudson with water.

About a quarter of a mile south of Mr. M'Clellan's on the east side of the mountain, the limestone and slate are seen almost in contact. The slaty divisions of the slate dip at a high angle to the east, while the overlying limestone dips about one foot in six to the west. About one-fourth to one-third of a mile farther south, the rock begins to dip in a southwardly direction from 5 to 10°; and still farther south is a ridge where the limestone is overturned, lying nearly vertical, and dipping about 80° to the east, as represented on Plate 24, fig. 5. The same upturned limestone may be seen two or three miles farther south in Livingston, and both contain the same limestones and fossils as the corresponding strata of Becraft's mountain.

Mount Bob, so called, is a hill about one hundred feet high, in the northwest part of Claverack, Columbia county. The western side is very steep, and a slope of debris of the blue compact limestone conceals a part of the rock of the same kind, which rises about twenty feet in a mural escarpment, and dips to the east as is represented on Plate 38, fig. 1, where (*a*) is the blue limestone, and (*b*) and (*c*) strata of grey fossiliferous limestone like that of Becraft's mountain. The slate underlies, apparently unconformable.

formably upon the subjacent slate rocks. I have traced these rocks to within a few feet of their junction in many places. Over a large part of Becraft's mountain, the strata slope from one to six degrees, both from the east and the west, towards the centre of the mountain, forming a very small segment of an inverted arch; and as the limestone is cavernous, and intersected by numerous fissures, most of the water which falls upon the mountain sinks into them, and is retained.* This peculiarity gives rise to a large limestone spring, which breaks out from the cliff on the north end of the mountain. It affords a constant and abundant supply of wholesome water for the city of Hudson.

The lower beds of limestone of Becraft's mountain are compact, of a dark blue, or nearly black color, and belong to the Water-lime group, and they break with a conchoidal fracture. The rock is easily dressed with a hammer, and is used for a building stone. It is beautiful and durable. The new Presbyterian church in Hudson is built of this material. Quarries have been extensively wrought in these beds, on the west side of the mountain. It has also been used for making lime.

The middle beds of Becraft's mountain are slaty limestones, and filled with fossil remains. Some layers are suitable for building, but generally they are adapted only for common wall stone. This is the same as the Catskill shaly limestone.

The upper beds of limestone in this mountain are distinctly crystalline, and replete with fossil remains. There are several quarries in these beds near the summit of the mountain. The stone is mostly employed for rough wall stone, for basement walls; and some of it has been used for making lime, for which purpose it is well adapted. This stone receives a high polish, and makes a beautiful grey marble with a tint of red. I have seen chimney pieces which were made of this material, that were very beautiful. Mr. Charles Darling, of Hudson, wrought one of the quarries as a marble some years ago, but the demand was not sufficient to justify its continuance. The following description is an accurate one, as might be inferred from the distinguished author of it, Prof. Silliman.

"The marble is of a greyish color, with a slight blush of red; its structure is semicrystalline, and in some places highly crystalline, especially in and around the organized bodies, which in vast numbers it embraces. Among them the encrinite is very conspicuous and frequent; and when the marble is polished, the organized bodies congealed in a bright calcareous bed, and often more brilliant themselves than the medium in which they are fixed, give it a very fine effect. This is particularly true in large slabs, which present a great diversity of appearance, and could scarcely be distinguished from the similar transition marble of the Peak of Derbyshire, which it greatly resembles, and quite equals in beauty and firmness." (*Silliman's Journal*, VI. p. 371.)

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* Vide Plate 24, fig. 6; and Plate 38, fig. 1.

9. Onondaga Salt Group.

This group of rocks, which is so largely developed in the central portion of the State, thins out in the First geological district, so that in many places it is absent; and where it is found, it is but a few feet in thickness.

The grey and porous yellow limestone of this group was recognized by Prof. Vanuxem at Sharon springs, overlying the Frankfort slates, and underlying the Helderberg series, opposite the mill, two hundred or three hundred yards north of the springs.

No salt water has been found in this group of rocks in the First district, unless the boring for the salt well on Fox creek, near Delhi, in Delaware county, penetrated into these rocks.

IV. ONTARIO DIVISION.

The rocks under this division may be classed under two groups:

1st. *The pyritous strata and red shales and grit;*
2d. *The Shawangunk grit, or conglomerate;* and a
3d. A range of rocks similar to the above, but the identity of which is not completely demonstrated.

1. Under the first of the above groups are included some thin strata lying between the Water-limestone group and the Shawangunk grit rock. These strata are frequently wanting altogether in the First geological district, and the thickness is less, generally, than thirty feet. The pyrites, in some cases, is found in the limestone, and sometimes in the Shawangunk grit, but usually in the intervening strata of greenish and red slate and shale.

At High falls on the Rondout in Marbletown, Ulster county, the pyritous stratum, which is there a slaty bluish limestone, occurs above the red shales that overlie the Shawangunk grit. The following is a section of the rocks at that place, above the bridge, and near the bend of the creek, on its left bank below the falls.

1. Cement rock	12 to 15	feet.
2. Limestone	10 to 30	"
3. Cement rock	6 to 8	"
4. *Pyritous slaty limestone*	4 to 10	"
5. Red shale with green spots, containing nodules and crystals of pyrites, and thin bands of grey compact limestone	15 to 20	"
6. Conglomerate or Shawangunk grit, unknown thickness.		

The red shale and slate, No. 5 of the above section, may, perhaps, for economical purposes, be called a *red marl.* It contains some lime, and there are several thin bands of limestone. The whole of this stratum has the aspect and composition of the red marl rock of Rockland county (new red sandstone), but has a different geological position.

The pyritous slaty limestone lying next above, is more or less argillaceous, and loaded with crystallized pyrites, which are continually decomposing and forming gypsum. The mineral thus formed coats the rocks in brilliant druses or flocky and acicular efflorescences. Epsom salts are also formed, if the taste is to be trusted; and Mr. Robinson, the owner of the locality, says, that the saline matter sparkles or deflagrates slightly when thrown on red hot coals. This sparkling would indicate the presence of nitrate of lime.

I advised Mr. Robinson to grind some of the pyritous limestone and red marl, as they are easily crushed; and when spread on the ground and exposed to the weather, both would give rise to the formation of gypsum, by the decomposition of the pyrites, and the combination of the sulphuric acid thus formed with the lime. He has since ground some of the rock, and made a trial of it as a substitute for gypsum, and has found that it answers the same purpose, promoting the growth of vegetation in a sensible degree. The slaty limestone is rich in pyrites, minute crystals of which are disseminated through its mass.

At Schoharie, near the bridge over the creek, the stratum containing the pyrites is exposed, underlying the Helderberg limestone series. This locality has been long known in consequence of the fine crystals, and groups of crystals, imbedded in the decomposed clayey green shale.

Many places were observed, where the same crumbling green shale, interlaminated with limestone, and containing an abundance of pyrites, was underlying the Helderberg limestone series. The slate, or dark colored shale, which contains the fibrous sulphate of baryta, lies directly below the pyritous rock in Carlisle and Sharon in Schoharie county.

The red rock, under various modifications of texture, is found on the northwest side of the Shawangunk mountains, and in the valley, in various places from near Rosendale to the New-Jersey line near Carpenter's point.

It is sometimes a red, and mottled red and green shale, with thin bands of limestone and balls of pyrites, like that described above at High falls; at others, it is a gritty shale or slate, or a chocolate or red colored grit rock, sometimes soft like freestone; at others a hard sonorous quartz rock. Passing from Wurtsboro' to Bloomingburgh, "it is crossed about one fourth of the distance up the mountain on its western side. It may also be seen in many places between that locality and the New-Jersey line." "In many places, hand specimens could not be distinguished from the New-Jersey sandstone."

On the road between the Shawangunk lead mine and the smelting house, the red rock is seen as a crumbling slaty sandstone of a chocolate color.

At the High falls of the Rondout in Marbletown, Ulster county, the red rock is a shale and fine slaty grit, spotted with green, and interlaminated with thin bands of limestone. It is there covered by the Water-lime series of the Helderberg division.

South of Rochester, Ulster county, near the locality of pyritous grit, is a red shale passing into a red clay* by exposure to the weather. It covers the white rock in patches in this vicinity. The grit rock is here waved in gentle swells, along axes of elevation which are subordinate to the two main axes of the Shawangunk mountains.† It is thought probable that beds of iron ore may be found in connection with this rock, which is highly ferruginous and frequently pyritiferous. Iron ore abounds in some parts of Pennsylvania and New-York in a similar geological position.

The observations made do not render it certain whether these red rocks are equivalent to the Onondaga salt group or the Medina sandstone; but it is thought probable, from some of the mineral characters, no fossils having been seen, that they belong to the epoch of the Medina sandstone, and that the subjacent Shawangunk grit is equivalent to the grey sandstone instead of the Oneida conglomerate.

2. Shawangunk‡ Grit or Conglomerate.

(Formation No. 4 of the Pennsylvania Geological Reports.)

This rock varies in texture from a conglomerate to a fine-grained grit rock, and it is almost entirely siliceous. It is generally white or light grey in color; but there is one bed near the upper part of its mass, that is red. Most of the layers of the rock are very hard; some are sandy, and others even slaty. Its colors are white, grey, greyish and reddish white, and brick red.

The mountain on which the grit rock abounds has taken its name from the predominant color of the rock; the word *Shawangunk* meaning, it is said, in the language of the aborigines of the country, *white rocks*.

The Shawangunk grit rock has been called "Millstone grit," by Professor Eaton; and it well deserves the name, both from its uses, and its similarity in texture and mineral composition, to the millstone grit of England; but as it has a different position, in the geological series, from that rock, which has now become a term indicating a conglomerate grit in a particular geological position, I have thought it better to use a local term for this formation, viz: *Shawangunk grit*.

The Shawangunk grit has not a *very* extensive range in the First geological district of New-York; but in New-Jersey and Pennsylvania, it is more largely developed. It extends in an almost unbroken range from the New-Jersey line on the top of the Shawangunk mountains, to Rosendale near Kingston, a distance of forty-three miles, where it disappears beneath

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* The clay beds and loams of many parts of the valley of the Rondout, and of this part in particular, are reddish, as is supposed from the intermixture of the materials derived from the "red rock."

† Dr. Horton's Report, in New-York Geological Report, 1839.

‡ *Shawangunk*, pronounced by the Indians *Shong-gun*, meaning *white stone*, is very appropriate. People now living, have had this explanation from the lips of the Indians.

the water limestone and the quaternary deposits of the Hudson valley.* On the higher parts of the Shawangunk mountains, it generally lies in nearly horizontal strata, often thick-bedded, and presenting mural escarpments of broken ends of the strata thirty to two hundred feet high. Some places on the eastern face of the mountain present the strata with a high dip to the east-southeast; but on the western face, the dip is almost uniformly to the west-northwest at variable angles. That part of the range about Wurtsboro', Ellenville and Wawarsing, shows a dip from thirty to sixty degrees to the west and northwest; but with some local exceptions, the dip of the grit rock towards either extremity of the range is less, and does not generally exceed eight to fifteen degrees.

The thickness of the Shawangunk grits is variable, but its maximum is believed to be less than five hundred feet, and its usual thickness is from sixty to one hundred and fifty feet.

The strata are traversed by two great systems of fracture; one longitudinal, and approaching more or less to the direction of the strike; the other transverse. Their usual directions are S. 20° W. and N. 20° E. for the first, and S. 60° E. and N. 60° W. for the second.

The Shawangunk mountains are less broken than any others with which I am acquainted, and which have been upheaved along an axis of elevation; but several breaks may be observed in them. These mountains continue, with but slight breaks, from the New-Jersey line near Carpenter's point, to opposite Ellenville and Wawarsing in Ulster county, where this ridge is crossed by great breaks and faults. The ridge then sinks and rapidly disappears beneath the valley, while several wrinkles or subordinate parallel axes of elevation spring up on the east at about the same height; run northeastward between the Stony kill, Mule kill, Sanders kill, &c., sink down gradually towards the mouths of those streams, and finally disappear below the valley in Rochester and Marbletown, or show their continuation only by low broken ridges of upheaved limestone. These axes of elevation are terminated, apparently, on the south, by the high cliffs along the transverse lines of fault. On the east of these minor axes, the second main axis of elevation takes its rise from High point, which is a high cliff of grit rock on the main fault, and ranges thence northeastward, more or less broken and dislocated by minor transverse and oblique faults, and diminishing in height, until the Shawangunk mountain and its grits, which envelope most of the higher parts, entirely disappear below the limestones and quaternary deposits at and near Rosendale. Several high points with mural fronts and ends are seen between Highpoint and Springtown, as Sam's point, Great Mogunk, Buntico point, &c., all of which are caused by faults along the main fractures of the mountain.

It has been mentioned that the wrinkles, or subordinate axes of elevation, seemed to terminate at the high rocky points on the southeast side of the Shawangunk mountain, as High point, Buntico point, Sam's point, Great Mogunk, &c. The termination is only apparent, caused by the transverse fractures. The ridges almost all slope down to the north and north-

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* This rock extends across a part of New-Jersey, from Carpenter's point to the Wallpack bend of the Delaware, where it enters Pennsylvania, ranges entirely across that State, Maryland and a part of Virginia, forming high mountains in many places. Its characters, both lithological and organic, are very constant over this long belt of country.

northeast, from where the main fractures cross each other, and the rocks disappear below the more recent formations, while their southwardly extremities almost always present high precipitous, and often vertical cliffs.

The continuation of the axis with which the wrinkles were connected, may be traced farther to the south in the Comfort hills of Orange county, between the Walkill and the Shawangunk rivers, and is probably an extension of that of Pochunk mountain on the New-Jersey line. The transverse fractures, and upheaves connected with them, and crossing the axis above mentioned, have given a great bend to the Mamakating valley to the eastward. This axis extends to the north by Catskill, Glen's falls, Saratoga lake, Baker's falls, and may with propriety be called the *Hudson axis*. It skirts the river more than one hundred miles.

The Shawangunk anticlinal axis forms the Shawangunk mountains, from the New-Jersey line to near Wawarsing, where it disappears, or is traced with difficulty. This is a continuation of that of the Kittatinny or Blue mountain of New-Jersey and Pennsylvania.

Diagrams and sections illustrating the superposition, derangements, etc. of the Shawangunk grit and the associated rocks, may be seen on Pl. 5, fig. 13; Pl. 6, fig. 7; Pl. 7, figs. 2, 3, 4; Pl. 8, fig. 4; Pl. 15, fig. 3; Pl. 26, figs. 4, 5, 6, 7, letter (*a*) grit, (*b*) water limestone; and Pl. 39, figs. 1, 2, 3.

Economical applications, and Mines.

The useful applications of the Shawangunk grits are not numerous; they are for mill-stones, building stones, and glass.

The firm coarse grits have been long quarried for mill-stones, and have been extensively used. They are known in market by the name of *Esopus millstones*.* They are still quarried to a small extent; but since the French buhr stone has been brought into common use for millstones, the Esopus stones are in less demand. Many *small millstones*, for family use, in grinding corn among the planters of the southern States, are still manufactured and sent to market.

The finer white and grey grits, which frequently resemble granular quartz, are well adapted for the manufacture of glass; and it is believed that the glass factory at Ellenville, Ulster county, makes use of this material. I know it was in contemplation to do so at the time of its erection.

These fine grits would make a beautiful and durable building material, which is as easily dressed as the common granites. Localities were seen, within less than two miles of the canal, where blocks could be procured three to five feet thick, and five to twenty feet in their other dimensions, without a seam, and on which the weather has produced no perceptible effect during the ages through which they have been exposed. Such rock as this the engi-

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* Esopus was the name of the township and village of Kingston, during the war of the revolution; and as these stones were quarried at no great distance, and were shipped from that vicinity, they have acquired the name of *Esopus millstones*. Esopus is now the name of a township and village a few miles south of Kingston.

neer may use without fear of hazarding his reputation; and his employer may feel certain that the structures built of it will not crumble down by the ordinary action of the weather in a few years, like some of our public works and private dwellings.

It is surprising to see how little attention is paid to the selection of materials for construction. Judging from what has come under my observation, the general impression must be, that *any solid stone may, with equal propriety, be put into the walls of buildings.* It is not so; and in our public works and expensive buildings, it is of great importance to select materials that will stand time unchanged. Some granites, limestones, sandstones, marbles and other rocks will stand the vicissitudes of the seasons for ages without any perceptible change; others nearly similar in appearance, and belonging to the same kinds of rocks, will crumble to sand or powder in a few years. An experienced eye is necessary to judge whether particular kinds of rock ought to be employed for structures that are intended to be permanent.

Metalliferous veins have been found in several localities in the Shawangunk grits. There are traditions that lead ore has been *cut out* of the Shawangunk mountain in many places by the Indians and hunters of former days with their hatchets, and melted to make their bullets. Traditions of this kind are said to have led to the discovery of the lead ores at Ellenville, Redbridge and Wurtsboro'. Lead ore has been discovered at many other points on the western side of the Shawangunk mountains, and in so many places, that it is thought probable a metalliferous vein may be almost coëxtensive in length with this range of mountains in Ulster, Sullivan and Orange counties.

The *Ellenville mine* is within one half mile of that village, at the base of the Shawangunk mountain. The vein is one of the transverse breaks of the strata, and ranges south sixty degrees east nearly vertical. The materials filling the vein are nearly the same as the grit rock that it traverses, more or less loaded with pyrites and crystallized quartz, and in some places with blende and galena. The vein is from two to three feet wide, and a copious spring flows from near its junction with the marsh below. The mine was first opened about twenty-three years ago, and some lead and zinc ores were obtained, that were reputed to be rich in silver. The lead ore was said to have been more abundant in the marsh than where the "mine" was opened, and it is supposed the Indians and hunters obtained their supplies from the marsh. The "mine" has been worked again within a few years by the North American Coal and Mining Company. In has been said that the adit level penetrated six hundred feet into the mountain, but no lead ore of importance seems to have been obtained. I should suppose, from the mass of rubbish, that the level cannot have been carried so far; and again, they would undoubtedly have perforated the grit rock, and entered the subjacent slate rocks, in less than that distance.

It is a fact well ascertained in mining, that metalliferous veins change in productiveness, and sometimes in the kind of ore, as they pass from one kind of rock to another. The grit rock of the Shawangunk mountain is overlaid by limestone,* and underlaid by the slate rocks

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* The limestone does not often cover the grit rock on the sides of this part of the mountains, but ranges along the valley, superposed in geological position.

of the Hudson-river group. Both these rocks are, in general, more metalliferous than the grit rocks; hence, the metalliferous veins of the grit, when traced into those rocks, or when the mines shall have been worked through the grit into them, may probably be more productive. The limestone was not seen in place at Ellenville, but was observed at no great distance, both up and down the valley, parallel to the mountain, dipping in the same direction; and some sink-holes, as they appeared to be, left no doubt on my mind that the limestone ranged along the valley between the canal and the base of the mountain, covered by alluvial deposits.

The *Ulster mine*, near Redbridge, and worked by the North American Coal and Mining Company, is situated on the Shawangunk mountain about one mile east of Redbridge, and six or seven from Wurtsboro', at an elevation of six or seven hundred feet above the valley. Two or three openings have been made. The first, which I believe is the uppermost one, I saw in 1837. It had been excavated during the preceding season and winter. It was on a line of fault, where the fractured grit rock abutted against the broken, irregular and bent edges of the slate of the Hudson slate group. It seemed as though the slate rock had been elevated, and its edges, by rubbing against the face of the grit, had been broken and bent very irregularly (Vide Pl. 39, fig. 1). The space between the slate and grit was filled with a siliceous gangue containing quartz crystals in great numbers and of large size, more or less interspersed with masses of blende, galena, copper pyrites and common pyrites. In 1838, the company had driven an adit level to intersect the vein at the depth of —— feet. This level, which intersects the strata of grit rock in a direction nearly perpendicular to their line of bearing, has been executed in the best manner, and is abundantly spacious, not only for drainage, but for taking out the ore on the most extensive scale, should it be found in quantity. Some lead ore has been obtained from this mine, but the quantity is believed not to amount to many tons. Whether this mine will ultimately be a profitable investment of capital, is doubtful; but it is thought that when the vein shall have been followed into the subjacent slate rock, the mine will probably prove more productive than it has thus far. It was intended to reëxamine this mine, when I could see the results of the explorations of the company, as it was intimated to me that they had determined to expend on it ten thousand dollars. I have not been able to reëxamine it.

The *Shawangunk mine* is located on the Shawangunk mountain, about two miles northeast of the flourishing village of Wurtsboro', in Sullivan county, at an elevation of six hundred or seven hundred feet above the Mamakating valley. The vein, in many places, has the aspect of a bed parallel to the contiguous strata of the grit rock of the mountain; but from a careful examination, it is believed to be a true vein, which, like some of the veins of magnetic iron ore that were examined in Putnam and Orange counties, runs between the strata, and then cuts obliquely across them, without altering its dip in any great degree (Vide Pl. 5, fig. 12). The strike of the vein corresponds nearly to that of the grit rock, but its *aggregate dip* is greater. The strata were observed to be more or less broken and bent, where the vein, after passing between them, crossed them obliquely. The grit rock on the mountain near the mine is traversed by small veins of quartz, which is more or less porous from the decomposition of its contained minerals. The vein on which the mine is worked, varies

from two to five feet in width; and the larger portion of its mass, as far as it has been explored, is a siliceous rock similar to that forming the roof and floor, except that it contains fragments and particles of greenish and blackish slate. The vein stone is more or less loaded with blende, galena, copper pyrites, iron pyrites and crystallized quartz. The blende and galena constitute probably $\frac{4}{5}\frac{9}{0}$ of the metalliferous contents of the vein, and these minerals are in general more or less intimately mixed.

The metalliferous part of the vein is from one to three feet thick in some parts; in others it narrows to a thin, almost linear seam; in some places the lead ore, in others the zinc ore, predominates. The ore, as an aggregate, may be said to lie in bunches, and the productiveness of different parts of the vein is very variable. When examining the mine, three masses of galena, free from other ores and from gangue, were taken out of the mine, weighing about 800, 1000 and 1400 pounds. One of these masses is believed to have been sent to the office of the company in New-York.

This mine is said to have been originally discovered by a hunter, and the first opening was made some forty or fifty feet from the present shaft of the mine. It was worked from the outcrop of the vein to a depth of about thirty feet, and some tons of lead ore (it is supposed thirty tons) were taken out of the mine. This opening was abandoned in consequence of the thinning of the metalliferous part of the vein, and the difficulty of raising the ore through an irregular and sloping shaft. A vertical shaft was in process of excavation at the time of my first visit in 1837, and it had reached the vein at that time. Lateral galleries have since been driven on the course of the vein. An adit level was driven perpendicular to the strike of the vein through the intervening strata of grit rock, fifty-two feet* below the mouth of the shaft, so as to intersect the vein at the distance of about two hundred feet from the main shaft. Galleries have been excavated laterally on the course of the vein from the extremity of the adit, and the southern one of these has been connected with the shaft. This adit and the contiguous galleries serve as a drainage level for the upper portions of the mine. Another adit level has been driven into the mountain, so as to intersect the vein at a perpendicular depth of seventy-five feet below the other, and the main shaft is continuous from this intersection, sloping up the course of the vein, to where this inclined shaft unites with the vertical one at the upper tier of galleries. Lateral galleries have been excavated on the course of the vein from the sides of the inclined part of the main shaft, and it was in these that the miners were employed at the time of my visit.

The ore is slidden down the inclined shaft to the lower adit level, whence it is removed to the ore heaps opposite this level. It is there picked and washed, and then sent to the smelting house on the bank of the canal, which, by the winding course of the road, is about a mile or a mile and a quarter.

The adit levels of this mine are spacious, and have been well executed; and as the rocks are indestructible, the preparations for working the mine may be considered as permanent improvements to last for ages, if it should be sufficiently productive to continue working it.

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* Vide Prof. Beck's Third Annual Report on Mineralogical Department of the Geological Survey, p. 49.

There is now a back* with an average depth of perhaps one hundred and fifty feet on the slope of the vein, ready for removal by the miner, and ready drained; so that if large bodies of ore exist there, they can now be removed without additional expense, except that merely of mining, since all the necessary preliminary expenses have already been incurred.

The advantages of these mines are,

1. Contiguity to water transportation, and nearness of market.
2. Great depth to which they may be drained without machinery.
3. Abundance and cheapness of fuel for smelting.

The disadvantages are,

1. Uncertainty of the quantity of ore.
2. The more or less intimate mixture of the galena and blende.
3. The siliceous nature of the gangue.

The explorations in progress will demonstrate the probability or improbability of the mines being prospectively productive.

The mixture of the galena and blende offers a practical difficulty in the smelting operation, and various methods have been tried to effect a separation, so as to be enabled to smelt the ore and obtain the lead; but they had not proved successful up to 1840. At the time of my visit, they were erecting shaking washing tables, which (the ore being first crushed or stamped, and then separated into uniform sizes by screens of different degrees of fineness,) has proved successful, and the ore can now be smelted.

The process for separating the blende or zinc ore also separates the greatest portion of the siliceous matter, so that the future value of the mines will depend only on the quantity of ore, and the expense of the separation.

There is a strong probability that there are valuable deposits of lead ore in the Shawangunk mountain, since so much lead ore has been taken from this and other mines, and from its having been found in so many places.

The zinc ore in the Shawangunk mine, as far as it has been worked, is believed to have exceeded the lead ore in quantity. At the time of my visit, they were taking out large quantities of both these ores.

It is thought probable that the ores may prove more abundant, and richer in lead, when the workings shall have reached the slate rocks that underlie the grit; but as the vein does not dip at a much greater angle than the strata, it is not probable that these rocks would be reached in this mine, without penetrating to at least the level of the valley, or five hundred to seven hundred feet below the present workings.

The lead ore of this mine contains some silver, but I have not ascertained the proportion. I cupelled a few grains of the lead obtained from some of the ore. A small but distinct globule of silver remained. Prof. Beck, of the mineralogical and chemical department of

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* The "*back*," in mining phraseology, means the mass of a vein that has not been removed, and lying above the galleries that have been opened.

the Geological Survey, has since cupelled some of the ore, and obtained silver.* Whether it exists in such quantity as to make its separation a matter of importance, is not ascertained.

Pyritous grit.

In some places, the upper strata of the Shawangunk grit are more or less loaded with pyrites. Occasionally this mineral forms a large portion of the rock, constituting the gangue, in which the pebbles and finer grains of siliceous matter are imbedded. Boulders of this variety of the grit rock were observed scattered over the country in the counties of Orange and Ulster, southeast of the Shawangunk mountains; and boulders of precisely similar appearance and composition were seen on Long island near Sand's point, and in other places.

A locality of this pyritous grit was examined south of Rochester, Ulster county, where the rock contained pyrites, and had been reputed to be a *silver mine*. A small excavation had been made. The only use to which it could be applied would be the manufacture of copperas, but it is not sufficiently abundant there to warrant any expenditure. This locality is near the base of the Shawangunk mountain, and one fourth of a mile south of the Mule kill, in the township of Rochester.

3. *Rocks similar in character to the Shawangunk grit, and the interstratified and overlying red rocks.*

These were observed in Orange county, and they extend from the New-Jersey line on the west side of Long pond, north-northeast to near Canterbury in Cornwall. They have not been traced continuously between the points indicated, but at intervals. This is the same formation as that described by Prof. H. D. Rodgers under the name of the Middle Secondary rocks of the Green-pond and Long-pond mountains.† Rocks of similar character are found on the east side of the Hudson valley, ranging from Fishkill near Matteawan, through Dutchess, Columbia, Rensselaer and Washington counties, into Vermont in West-Poultney, a distance of two hundred miles from their southern termination in New-Jersey. Prof. Rodgers is doubtful about the geological age of this formation, but he inclines to the opinion that it is equivalent to the sandstones of the Middle Secondary (New Red-sandstone), which are associated with trappean rocks in New-Jersey and New-York. The observations on the geological survey of the First district of New-York do not *quite demonstrate* the age of this rock; but if the red slates and grits on the east side of the Hudson, which are the same as those of Pine hill in Cornwall, Orange county, are the same as those of Bellvale mountain near Long pond, and the Green-pond mountain, which they strongly resemble, and of which they appear to be an extension, they are older than the Middle Secondary sandstone (New Red-sandstone) of New-Jersey, to which Prof. Rodgers inclines to refer them, and are probably the geologi-

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* Vide Assembly Document No. 275, for 1839, p. 51.

† Final Geological Report of New-Jersey, pp. 171, 175.

cal equivalents, and in fact identical with the red rocks overlying and interstratified with the upper part of the Shawangunk grit. At Townsend's iron mine in Cornwall, the decomposed Delthyris shales, with their characteristic fossils (one of the members of the Helderberg division), are seen. and the red slates of the formation under consideration adjacent, and a coarse pebble rock, sometimes white, sometimes red like the Shawangunk grit, also near at hand in a nearly vertical position.* This locality is a mile or two northeast of the northeast point of Skunnemunk mountain in Cornwall, Orange county.

The whole extent of this range of red and grit rocks, from the New-Jersey line on Bellvale mountain to Townsend's mine in Cornwall, is in a highly inclined position, often vertical; and the same is true of the similar rocks which are supposed to be an extension of this range from Fishkill through Dutchess, Columbia, Rensselaer and Washington counties, into the State of Vermont.

The association of the Helderberg limestone with these red slates, grits, and red and white conglomerates, may be considered as very strong evidence, almost decisive, that these red rocks are the equivalents of those of the west side of the Shawangunk mountain, and of the central portions of New-York (the Medina sandstones, Oneida conglomerate, Onondaga salt group, and grey sandstone), instead of the red sandstones of the middle secondary of Rockland county and of New-Jersey.

Dr. William Horton, who made most of the detailed examinations of Orange county, mentions the following localities of these red and grit rocks on the eastern side of the Walkill valley, along the base and in and near the Highlands.

"The same red rock is found in the town of Blooming-grove, but in a different situation and position. It is first found in this town on the southeast side of the Round hill.

"Round hill, like the Highland ranges, is primitive, and here the grit rock inclines against and rests upon it. The grit rock is regularly stratified; line of bearing same as in Shawangunk mountain, but it dips to the southeast. It passes through all kinds of composition, from compact to soft and slaty on one hand, to a coarse conglomerate on the other; and all shades of color, from milk-white to brick-red. From the point mentioned, it extends northeast nearly four miles, until intercepted in its line of bearing by a part of Woodcock mountain, which is primitive.

"A similar rock is again found in the southeastern face of Skunnemunk mountain, and at its base. But here it is interstratified with the greywacke and greywacke slate; and while all the colors already mentioned exist here also, there are some layers which are different. The pebbles of which these layers are composed are much larger, and about half of them are very white, and the remainder very red. All the pebbles are smooth, as if water-worn.

"These layers extend as far south as Skunnemunk mountain, and about two miles farther

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* Vide Plate 5, fig. 13. The diagram may not convey a very correct idea of the position of these rocks. The stratification is very much deranged in the vicinity, being on one of the axes of the disturbance, and the order of superposition is not considered as definitely ascertained. An important question may be settled by a rigid examination of that vicinity.

north than the mountain itself does. The hematite mine of Mr. Thomas Townsend is connected with this rock, two and a half miles west of Canterbury.

"Pine hill, a ridge next southeast of Skunnemunk, is composed of this rock; it is near three miles long, narrow, and somewhat elevated. In this hill the rock is almost entirely red, and can be quarried in handsome blocks for building. Woodbury furnace is built of stone from Pine hill; it has all the appearance of freestone, except that it is rather more variegated than most American sandstones. It bears a high temperature very well. No fossils have been seen in this rock any where.

"Bellvale mountain extends quite across the town of Warwick. The southeast side, the top, and about one-third of the descent on the northwest side, are composed of greywacke and greywacke slate, standing nearly vertical. Its colors are grey, greenish and bluish grey, and brick red. Many of the layers are completely chequered by veins of milky quartz traversing them in all directions. While it passes on one hand into greywacke slate or greywacke shale, on the other it becomes a perfect conglomerate.

"Skunnemunk is similar to Bellvale mountain, passing unbroken nearly across Monroe. Its southeast side, top and part of northwest side are greywacke in all the same varieties. It is not in a line with Bellvale mountain, neither do their lines of bearing quite coincide. Most of this mountain has the dip, etc. of Bellvale mountain; but *High point* has the rock dipping to the *east*, and some part of it even to the *northeast*.

"On some of the small ridges northeast of Bellvale mountain, the greywacke is seen forming their northwestern sides, while the opposite or southeast side is primitive rock. One of these may be seen a mile west of the Friends' meeting-house, in Monroe. In these cases, the line of bearing and dip of the greywacke coincide with those of the primitive, and the greywacke has the appearance of passing beneath the primitive rock. At the western base of Goosepond mountain and of Sugarloaf Mate, the slate has the same position in reference to the primitive, and exhibits precisely the same appearances. These circumstances being precisely similar, are mentioned together, so that future visiters to the neighborhood may notice both. In many places, both rocks are visible but a few feet apart, but I have not seen them in actual contact. This position of the two rocks so different in age, is singular and interesting. In the banks of the stream from the village of Canterbury to the Hudson, nearly all colors and forms of greywacke may be seen; also in the banks of the Hudson, from Cornwall landing, a mile up the river, to the mouth of the creek. *Pine hill* east of Skunnemunk, is a greywacke ridge, composed almost entirely of the red, slaty, compact and conglomerate forms. Woodbury furnace is built from the red stone of this hill. It makes an excellent building material, and resembles in all respects sandstone.

"Fine quarries of the blue flagging stone might be opened in Skunnemunk mountain, and of the red, resembling the sandstone, in Pine hill."*

The sections on Pl. 13, fig. 6; Pl. 16, fig. 2; Pl. 18, fig. 1; and Pl. 18, figs. 1 and 2,

* Dr. W. Horton's Geological Report, 1839: New-York Geological Report, 1839, p. 146.

show the extension of this rock to the north on the east side of the Hudson, in Dutchess and Columbia counties. The rock was seen in hundreds of localities in those counties, in Rensselaer and Washington counties, and in Vermont. I infer that these red rocks are the same range, and of the same age as those extending from Canterbury, through Bellvale mountain by Long pond, to Green-pond mountain in New-Jersey, for the following reasons, viz :

1. It is an apparent extension of the same geological formation in the same direction.

2. The rocks have similar general characters and geological associations, though frequently modified in appearance by causes contemporaneous with, or subsequent to the period at which they were placed in their present highly inclined position.

3. There are no rocks of similar color and characters, lower in the geological series ; and none higher, except those of the Catskill division ; but these latter have not similar geological associations, and besides they have a vastly greater thickness, where they are undisturbed, not many miles distant.

In some places the same red rocks occupy two or three parallel belts, one or two miles from each other. Limestone was frequently seen associated with these red rocks in the valley of Smith's clove in Orange county, and in the counties on the east of the Hudson river ; but no fossil remains were observed in it at any other place than Townsend's iron mine in Cornwall.

These red slate and grit rocks, like some others that will be described in the Taconic system, cross the belt of primary mountainous country called the Highlands, from north-northeast to south-southwest, and emerge on the southeast side, but they pursue a course parallel to the ridges of the Highlands.*

The period of the elevation or tilting of these rocks into their present highly inclined position, will be considered in another part of this volume.

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* There are no continuous ridges of mountains in the Highlands, of more than a few miles in length, in consequence of the interruptions caused by dislocations and lateral heaves of masses of the strata. The hills of similar rocks succeed each other in echellon lines, which seem to have been caused by lateral heaves along the lines of fault. In consequence of this, neither the *line of outcrop* nor the *line of bearing* is parallel to the *general direction of the Highlands*, but ridge succeeds ridge, each of which runs out and diminishes in height until it disappears in a northwardly direction below the rocks, which are generally considered of more recent origin. For example, a traveller passing in Rockland county from southwest to northeast, along the base of any of the large hills of a mountain, if he continues his course without turning off to the east, around the point of a succeeding mountain, will soon find himself in the midst of the Highlands. If he be travelling in the opposite direction, along the base of one of the mountains, and continue his course, he will find himself receding farther and farther from the mountains as he passes each succeeding terminating hill. If he be travelling on the northwest flank of the mountains, the reverse will hold true; and progressing southwest from Cornwall, New-Windsor, or Newburgh, he will soon find himself entering the mountains, and following through the valleys, will emerge on the southeast face of the Highlands. These valleys are called "cloves," and Smith's clove is a noted example. It is the one through which the New-York and Newburgh turnpike passes, without ascending more than a few hundred feet, and is frequently referred to in this volume.

The Ramapo river flows through this clove to the south, while another stream, a branch of Murderer's creek, flows in the opposite direction. The Erie railroad crosses the Highlands through the south part of Smith's clove, to near the head of the Ramapo.

V. CHAMPLAIN DIVISION.

GENERAL REMARKS.

This division includes those rocks that have been described in the annual reports of the First geological district, under the name of the *Hudson-river slate series*,* and *Hudson slate group*.

It consists of a series of slates, shales, grits, limestones, and siliceous and calcareous breccias and conglomerates. Some plutonic rocks which have been intruded among those of the above series, have modified their aspect in many places, and formed metamorphic rocks. They will all be described in their proper order.

The rocks of the Champlain division occupy a belt of country between the Shawangunk mountains and the Highlands on the New-Jersey line, ranging thence eastward and northward by Kingston, Saugerties, Coxsackie, Coeymans, New-Baltimore, Schenectady, Ballston, Saratoga, Glensfalls, Fort-Ann, and Whitehall, for its western outline; and with the Highlands and their extension northwards, a few miles west of the lines of Connecticut, Massachusetts and Vermont for its eastern boundary. On the north, it extends far into Vermont, and probably into Canada; on the west, up the Mohawk valley and across the State of New-York, and occupies a vast extent of territory in Ohio, Kentucky, Indiana, Illinois and various western and southwestern states and territories; to the south it extends across New-Jersey, Pennsylvania, Maryland, Virginia, and still farther, but its southern limits have not been thoroughly explored.

In the First geological district of New-York it consists of the following members or groups, viz:

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* The division of the fossiliferous rocks of the First geological district, as proposed in the Fourth Annual Report, (1840,) was one of convenience, and founded in nature, and as affording means of easily tracing the groups of strata. This division of the rocks has been substantially retained by the Board of Geologists, the Hudson slate series being divided into the Champlain division and Taconic system, the Catskill mountain series divided into the Catskill and Erie divisions, and the Shawangunk series called the Ontario division. Although there is scarcely a doubt as to what formations in Europe these are equivalent, yet it has been thought preferable to describe groups of rocks as they are, instead of striving to identify them with those of other countries, which must necessarily differ from them in some respects. Geological equivalents can be settled in a permanent manner, when all the facts of superposition, fossils, and the more or less local extent of subordinate strata, shall have been definitely ascertained. If that time has not yet arrived, it is believed to be near at hand; the superposition of the New-York rocks and those of several of the other States being now known, and the fossils are undergoing a rigid examination.

1. Hudson-river group, 2. Utica slate.	} No. 3	Pennsylvania	survey.
3. Trenton limestone, 4. Black-river limestone, 5. Calciferous group.	} No. 2	do	do.
6. Potsdam sandstone,	No. 1	do	do.*

These rocks form a natural series, and seem to be due to certain modifications of the same cause acting over a vast area in North America. They are supposed to underlie three-fourths of the whole territory of the United States, and to occupy the surface of one-half, the remainder being covered by depositions of more recent date.

Along their eastern line of outcrop these strata have been much deranged in position since their deposition; having been broken up and tilled at various angles, bent, wrinkled and contorted in almost every conceivable manner, and elevated into hills and mountain chains. The whole breadth of their outcrop on the east, from Vermont to Carolina, except at the outlet of the valley of the Mohawk, is upturned and deranged over a breadth from five to more than fifty miles. The whole may be referred to one great axis of disturbance, with many subordinate parallel fractures, and synclinal and anti-clinal axes, ranging from Canada to Carolina, and nearly parallel to the general trend of the coast.

Numerous sections and diagrams illustrate facts observed in the First geological district of New-York, along this axis of disturbance;† but others equally striking, and some of arched and wrinkled strata on a magnificent scale, may be seen in Maryland, along the route of the National road, between Hagerstown and Cumberland; and others might be mentioned in Virginia and Pennsylvania, on this belt of disturbance. These and numerous others in those States will doubtless be described by Professors H. D. Rodgers and W. B. Rodgers, the geologists of those States.

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* The synonims of the above members of the Champlain division, as used in the geological reports of the States, and Eaton's Geology, are subjoined.

HUDSON-RIVER GROUP.....	Frankfort slate group; Frankfort slate and rubblestone; Green slate and rubblestone; Pulaski shales; Greywacke, G. slate, G. shale, Slaty greywacke and Transition argillite of the Annual Geological Reports; Greywacke and Metalliferous greywacke of Eaton. No. 3 of the Pennsylvania Survey.
UTICA SLATE.....	Mohawk slate; Black slate and shale; Fairfield slate; Graptolitic slate, Transition argillite, Wacke slate, Glazed slate of Eaton. No. 3 of the Pennsylvania Survey.
TRENTON LIMESTONE.....	Metalliferous limerock of Eaton; Trenton limestone of geological reports. No. 2 of the Pennsylvania Survey. Cliff limestone of the Ohio Survey.
BLACK-RIVER LIMESTONE...	Mohawk limestone; Birdseye limestone; Base of the Trenton limestone; Bald mountain limestone; Blue limestone; Chazy limestone; Black marble of Isle la Motte; Neeleytown limestone; Seven-foot tier of the Geological Reports; Metalliferous limerock, Transition, Sparry and Chequered limerocks of Eaton. No. 2 of the Pennsylvania Survey.
CALCIFEROUS GROUP.....	Calciferous sandrock, and Transition sandrock of Eaton; Barnegate limestone, Newburgh limestone; Warwick limestone. No. 2 of the Pennsylvania Survey.
POTSDAM SANDSTONE.....	Potsdam sandstone; Keeseville sandstone. No. 1 of the Pennsylvania Survey.

† Vide Pl. 6, fig. 7; Pl. 12, fig. 2 to 8; Pl. 18; Pl. 28, fig. 1, 2, 3;
— 7, — 1 to 9; — 13, — 1 to 6; — 23, fig. 1 to 8; — 29;
— 8, — 1 to 10; — 14, — 1 to 7; — 24, — 1 to 6; — 36, fig. 6, 7;
— 9, — 1 to 21; — 15; — 25, — 1, 2, 4; — 38, — 1 to 14;
— 10, — 1 to 14; — 16; — 26, — 1 to 7; — 39, — 1 to 4;
— 11, — 1 to 14; — 17; — 27, — 5, 7, 8, 9; — 40, — 3 to 10.

In the Fourth Annual Geological Report of New-York, this series of rocks, under the name of the Hudson slate group, was briefly described as an alteration of the shales, slates and limestones, with siliceous and calcareous breccias; and as underlying unconformably, with a few exceptions, the superincumbent rocks. This is true in the immediate valley of the Hudson, and westward to the great line of fracture. Beyond that, to the west, the superincumbent rocks overlie this series conformably.

This is an important fact, inasmuch as it demonstrates the geological period of this, as one of the several upheaving actions that have broken up and deranged the position of the pre-existing strata.

The Helderberg limestone series at Becraft's mountain, Pine mountain, Wilbur, and many other localities, in a position nearly horizontal, overlies unconformably the highly inclined subjacent rocks; while in the Mohawk valley, and generally west of the great fracture, they are nearly horizontal and conformable. Other elevatory movements have occurred since the deposition of the superior rocks, by which they have partaken of the general movement, been broken, contorted, upheaved, and even overturned in some localities, so as to invert the original order of superposition.

It has been observed that some of the rocks in the valley of the Hudson, which lie at a high angle of inclination, and dip in the same direction as the proper slates of the Hudson rocks, are similar, and it is believed identical with the Shawangunk grit, and the masses superposed upon it.*

Topographical and agricultural characters.

The agricultural character of a district is dependent on the rocky masses under the soil, their stratification, the materials of which the soil is composed, and the topographical character of the country.

The two first of these points may be illustrated in the district under examination in this report, by calling the attention of the reader to those portions of Schenectady county, and to Rensselaer, Washington and other counties, that have the Hudson slate rocks beneath their soils, and that lie higher in level than the ancient alluvion of clay and sand of the Hudson river valley. These rocks are alternations of slates, with slaty and fine grained sandstones, and hard grit rocks. The strata of slate, and many of those of the other rocks, are nearly or quite impervious to water. In Schenectady county, the strata of these rocks lie nearly horizontal, are impervious to water, and by decomposition form a highly argillaceous soil. The consequence is, that the hill lands are generally cold and wet soils. In portions of the

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* A rock that bears some resemblance to the Shawangunk grit, ranges through the county of Rensselaer and northern part of Columbia, forming a part of Petersburgh mountain in the former, and the high range of land west of Lebanon valley in the latter county. It is a greenish and bluish hard siliceous grit, sometimes granular, sometimes brecciated, and at others a conglomerate or puddingstone. It contains no organic remains as far as is yet known, and it has been applied to no use except as a rough wall stone. The same rock, with some modifications, ranges through a part of Dutchess, Orange and Ulster counties.

other counties named, (and portions of Columbia, Dutchess, Orange, Ulster, Greene, Albany and Saratoga, might also be mentioned,) the rocks are the same, but the strata dip at a high angle, the rock more readily crumbles by the action of the weather on its edges, while the inclination of the strata enables the water to sink and be conducted off between the layers and through the joints of the rock, to break out in springs at a lower level. The hilly character of these counties also enables the water to drain in part from the surface more freely than if the lands were more level, and the consequence is a mellow, warm and dry soil. The rocks here spoken of range through Orange county, between the Highland and Shawangunk mountains; thence through the east parts of Ulster, Greene, Albany, Schenectady and Saratoga, on the right bank of the Hudson; and through the west part of Dutchess, Columbia and Rensselaer counties, on the left bank of that stream. This range of rocks occupies a diagonal belt of country in the county of Washington.

1. Hudson-river Group.

Synonims. *Frankfort slate group*, *Frankfort slate* and *rubblestone*, *Greywacke*, *Greywacke slate*, *G. shale*, *Slaty greywacke*, *Transition argillite*, *Pulaski shales*, *Green slate* and *rubblestone*, of the Annual Reports; *Greywacke* and *Metalliferous greywacke* of Eaton. No. 3 of the Pennsylvania Survey.

The rocks of this group are mostly slates, shales, and grey, slaty and thick-bedded grits, that have heretofore been called *Greywacke slate*, *Greywacke shale*, *Greywacke*, and *Slaty greywacke*. The slates and shales are generally dark brown, blue and black; and the grits are grey, greenish and bluish grey. They are stratified and conformable, alternating a great number of times without any regular order of alternation.

These rocks contain *few fossils* except fucoids, and these are extremely abundant in some of the strata. There are at least five species which will be figured and described in the Palæontological Report. The species above alluded to are found in the slates and shales, but there are others on the surfaces of the slaty grits peculiar to these rocks.

A few specimens of testacea only have been found in this group, although it is well exposed to view over a great extent of country in the First geological district. A few were observed at the falls of the Walkill at Dashville, Ulster county, and near the villages of Walden and Sugarloaf in Orange county.

The *thickness* of this group could not be accurately ascertained in any part of the Hudson and Champlain valley, in consequence of the rocks having been deranged, upheaved and tilted in almost every direction, where they are visible; but in the valleys of Norman's kill, the Mohawk river, and the Schoharie kill, they are beautifully exposed to view, and can be studied with any required degree of minuteness. The rocks in those valleys, and those of their tributaries in Albany, Schenectady and Schoharie counties, dip at small angles to the west-northwest, west and southwest. No actual measurements of these strata have been made, but it is estimated that they have a thickness of from five to eight hundred feet.

Beautiful sections of parts of this group of rocks may be examined on the Schoharie kill, at and near Burton's bridge, and in numerous localities between that place and Esperance; also at the bend of the Schoharie kill, between Central-bridge and Sloansville, and near the mouths of Vly creek and Cripplebush kill; and on the Mohawk near the aqueduct, the banks of the Norman's kill, two miles southwest of Albany, and numerous places on the shore of the Hudson.

Among the *undisturbed* strata, we see none of the *diagonal cleavage* of the slate rocks, which is so common a character of the *deranged* strata of the Champlain division, throughout their extent in the First geological district.*

The rocks of this group occupy a large part of Orange, Albany, Schenectady, Saratoga, Washington, Rensselaer, Columbia and Dutchess, and small portions of Sullivan, Ulster and Greene counties.

Local details of the Hudson-river group.

Orange County.

Dr. Horton† describes the rocks of this group under the name of *Transition argillite*, and says,

"This rock occupies a large extent of surface in this county. Its general direction is north-northeast and south-southwest, varying to northeast and southwest. Some ridges and elevations differ considerably from this course; but these are partial, and extend only short distances. Its color differs from light ash grey through all shades to black. Its hardness, in some localities, being the softest kind of clay slate; in others, hard and siliceous; while others still possess this property in all intermediate degrees. It is every where regularly *stratified*, although the strata in many places are singularly bent and contorted.

"Its *dip* is uniformly to the southeast, differing considerably in its amount in different places. In some localities its position is nearly vertical, while in others the angle of its dip will scarcely reach thirty degrees. Perhaps the angle of fifty degrees will be nearest that of its general dip. A little way from the western base of the Highlands, it extends from near the line of New-Jersey in the town of Warwick, uninterruptedly to the Hudson river in Cornwall, New-Windsor and Newburgh. On the west side of the Walkill river, the same rock comes out of New-Jersey, and passes down this stream until it enters Ulster county, and in all this course there is no rock resting upon it.

"With the exception of the two ranges mentioned above, it is often overlaid by other rocks; these will be noticed hereafter. It forms the bank of the Hudson, from about three and a half miles above Newburgh, to Cornwall landing, which may be about nine miles.

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* Vide Plate 10, figures 3, 4, 5, 6, 7, 8, 9, 10; Pl. 29, lateral figures; and Pl. 38, fig. 10.

† Dr. Horton was employed as one of the assistants on the Geological Survey, to make the detailed examination of Orange county.

Wherever this rock is seen in this county, it is more or less stratified with greywacke and greywacke slate.

"Fine opportunities for observing these alternations are afforded in the town of Montgomery, in the village of Walden, in the bed and banks of the Walkill, and the banks of the aqueduct which supplies water to the factories; also in the quarries on the west bank of the stream, opposite the factories; also in the bed and banks of the Walkill, a little below the village of Montgomery; also in Mount-Hope, at and near the village; at Unionville in Minisink, near the New-Jersey line; in the banks of the Hudson at Newburgh, and on the road from Newburgh to Hampton, about a mile from the former place.

"On the whole, the alternations of the greywacke are less frequent and less extensive on the east and southeast side of the Walkill, than on the west and southwest. As we approach the foot and ascend the southeastern face of the Shawangunk mountain, the greywacke *covers more surface* than the argillite.

"This rock forms a kind of cuneiform termination in Warwick, about half a mile from the New-Jersey line; the limestone meeting round this termination from both sides. From this point, proceeding northeast, the argillite widens into an elevated ridge of rich land, called Long ridge, which extends across this town into Goshen. It forms the surface rock over three-quarters of Goshen, nearly all Blooming-grove west of the mountains, parts of Cornwall and New-Windsor, a large part of Newburgh, all Montgomery, all Hamptonburgh except two or three farms, most of the towns of Crawford and Walkill, part of the town of Mount-Hope, and most of Minisink. It rises almost to the top of the Shawangunk mountain, the whole breadth of the county at that part.

"The argillite, and its associated greywacke and greywacke slate, no where rise into lofty mountains in Orange county. When this circumstance is recollected, and taken in connection with what has been stated of the extent of this rock forming the great valley of the Walkill, it will be perceived at once how greatly it modifies the surface of the country. There is another remark should be made in this place, in relation to the rock of which we have been speaking. The argillite portion of the county of Orange embraces an unusual *number* and extent of swamps, or, as they are called, *bog meadows*. They are *all* formed by bars of argillite rock across their outlets; this is true from the great drowned lands down to those which cover only an acre or two of surface. *The useful* purposes to which this rock is applied, are not numerous. The most important one at present, is in the construction of fire-places and the lining of furnaces. When placed with the edges of the laminæ to the fire, it remains for a long time uninjured. Some varieties in this county, which are not siliceous, are excelled by no stone, for this purpose. The quarries of Mr. Bulmer, at Sugar-loaf, furnish excellent stone in abundance; they are sold at from two dollars to five dollars per load, at the quarry. It is also quarried to some extent on the western shore of Big Long pond, as a fire-stone. Roof slate might be obtained abundantly, very similar to the Welch slate, but none is wrought for this purpose.

"The argillite is also employed to some extent in the construction and repair of roads; it is, however, but a poor material for this purpose. The surface edges of the rock are generally employed, and these of the variety containing the largest proportion of clay. The wheels soon reduce it to powder so fine that the wind drifts it when dry, and the water washes it away when wet.

"Anthracite is also disseminated in the greywacke in masses from the size of a pin head to that of a pea, so as to give the rock quite a handsome appearance. This is strikingly the case at Walden, on the northwest bank of the Walkill.

"Beds of siliceous slate and lydian stone are embraced in this argillite. I have also seen graphic slate, but it is not abundant. In some places, the greywacke associated with the argillite forms a tolerably good building stone. It quarries very well, and works well under the hammer."*

Veins traverse the rocks of this group in various directions, but they are generally the same as those of the systems of joints. They are filled with quartz and carbonate of lime. The quartz is frequently crystallized, and the crystals adhere to the sides of the fissures, the remainder of the vein being vacant, or filled with carbonate of lime. Fibrous quartz and amorphous quartz, calcareous spar and satin spar, the former in fine crystals, and the latter in short fibres with a silky lustre, are often found in the veins. Small but brilliant crystals of pyrites are not uncommon in the veins in the grits and slates of this group.

Wherever these rocks are quarried or exposed to view, either artificially or naturally, they are found to be upturned on their edges, or dip at a high angle, and are frequently curiously bent, contorted and broken, as if pitched together heterogeneously. The rocks are evidently sedimentary, and cannot have been formed in the position in which they now lie; for, layers of sand and mud cannot lie in vertical laminæ unsupported, and these rocks were evidently formed of sand and mud in parallel successive laminæ and strata. The principal lines of fracture and of disturbance of the strata, with the effects, the phenomena connected with them, and the relative periods at which they occurred, will be discussed in a subsequent part of this volume.

Sullivan County.

A small portion of this county is occupied by this group as the surface rock. The mass of the Shawangunk mountain is formed of rocks belonging to this group, except the small portion occupied by the Shawangunk grit. They are similar in character to those of Orange.

Ulster and Greene Counties.

The rocks of the Hudson-river group occupy the east and southeast parts of Ulster and Greene counties. The slates occur at Kingston point. They are also seen at Pine mountain,

* Third Annual Geological Report, 1839.

and at Lawrence's quarries opposite Wilbur, underlying the limestones of the Helderberg division unconformably (Pl. 24, fig. 1). They form the banks of the Walkill at Eddyville and Dashville; the Shawangunk and Marlborough mountains, and Huzzy hill; the banks of the Hudson where the rocks are exposed from the mouth of the Walkill to the Highlands on the south, and to Baker's falls on the north.

These rocks dip to the east-southeast, with some local exceptions, at a very high angle.

The slate rocks form the mass of the strata from Marlborough five miles west towards Pleasant-valley, some of which are black, and more or less loaded with carbon. The blackness of some of these strata, and the impressions of plants (graptolites) contained in them, have led to excavations for coal; but, as might be supposed, none has been discovered. The Marlborough mountain, or Breakneck hill, as it is called, is a coarsely stratified grit rock, containing in some places some carbonate of lime. The rock is not coarse-grained, but is hard, and at a little distance, and even near, has the general aspect of a primary rock. Slate, interstratified with coarser grits, succeeds on the west of Marlborough mountain, and extends to Pleasant-valley.

Between Rosendale and Dashville, the grits are beautifully exposed on the banks of the Walkill, and particularly opposite the bridge across the Walkill, and between that place and Dashville. They form strata one and a half to five feet thick, of solid greywacke as it has been called, with thin layers of shale between. These rocks are intersected by two systems of joints in nearly vertical planes, ranging N. 20° W. and N. 70° E. These seams or joints make faces to the blocks nearly as regular and smooth as if they had been sawed. The falls at Dashville exhibit a fine section of some of these rocks, and a fault and derangement may here be seen (Vide Pl. 7, fig. 7). The strata are nearly horizontal above the fall; but at a break and fissure at the foot of the fall, the contortion begins, as represented on the plate above mentioned. On the right bank of the stream, the whole inverted arch may be traced, as represented on Pl. 7, fig. 8. The strata have been cracked, and opened on the extrados of the curves, as if they had been consolidated before they were bent, and had cracked as represented on Pl. 7, fig. 8, or more distinctly on Pl. 7, fig. 8′. These cracks have since been filled with quartz and calcareous spar. The hill east of Dashville shows a part of the reversed arch. Drusy quartz and fragments of anthracite were observed in the grit rocks near the bridge, a quarter of a mile above Dashville, and some few fossil shells.

Marlborough mountain, which extends from Orange county and terminates in Huzzy hill, in the angle between the junction of the Hudson and Walkill rivers, is composed of the grits and slates of this group. The strata are inclined at a high angle, dipping generally thirty to eighty degrees to the east-southeast. This mountain ranges nearly parallel to the Hudson, and has an elevation in some places eight hundred to one thousand one hundred feet. This range of hills scarcely deserves the name of a mountain, but is called the Marlborough mountain. It is on one of the breaks, or lines of upheaving action, parallel to the Hudson river anticlinal axis.

A brecciated rock, somewhat peculiar in character, occurs in the Marlborough mountain in

the Hudson-river group. It is composed of angular fragments of the siliceous and calciferous rocks of the lower part of the Champlain division, cemented together into a hard, tough, siliceous and sometimes a calcareo-siliceous breccia, that makes beautiful cabinet specimens of rich and variegated colors. Boulders of this rock are found in the valleys of the southeast part of Ulster county, and as far south as Hamptonburgh and Goshen in Orange county.

At Eddyville in Ulster county, contortions of the slate rocks of the group under consideration are finely exposed to view in the banks of the Walkill (Vide Plate 9, fig. 11).

Near Saugerties, in the banks of the Esopus creek, the rocks of the Hudson-river group are well exposed, upturned at a high angle, and in some places contorted. They are also exposed in many places between Saugerties and Kingston on the south, and Catskill on the north, and particularly between Saugerties and Bristol.

Although the *actual junction* of the rocks of the Hudson-river group with those of the Helderberg division was not observed between Kingston and Catskill, they were seen in many places so *nearly* in contact, and unconformable, as to leave scarcely a doubt that they were really unconformable (Vide Pl. 7, fig. 9; Pl. 8, figs. 1, 2, 3, 7). The actual junction was seen only at Lawrence's quarries opposite Wilbur (Vide Pl. 26, fig. 1), and at Pine hill, both of which are near Kingston, and in both these places the strata were unconformable.

The only supposable case, if these strata are not generally unconformable where the rocks have been deranged, is, that the anticlinal axis which ranges along the base of this long mural escarpment of the limestones of the Helderberg division, has caused all the strata of the Hudson-river group, over a breadth of many miles eastward from this cliff, to be upturned in a position nearly vertical, almost in contact with the limestones, which are but slightly elevated, dipping moderately to the westward, while the slate generally dips to the eastward. (Vide Pl. 38, fig. 14, which is a section from Catskill westward to the stone bridge across the Kaaterskill; and fig. 13, near the mineral spring, three miles west of Athens in Greene county; and Plate 11, fig. 13.)

Numerous facts similar in character to these have been observed in several places along the anticlinal axis between Catskill and Sandyhill, where the slate rocks were nearly undisturbed on the west side of the anticlinal axis, while they were upturned at a high angle on the east; but the more numerous facts seem to demonstrate that these strata have been deranged by two (perhaps more) distinct, successive periods of disturbance, with a long interval of repose between them; that one broke up the strata on the east side of this axis, afterwards the strata of the Helderberg division were deposited, and since then the upheaving action has occurred along this same line, that has elevated the strata of the Hudson valley, and given the westerly dip to those that were before horizontal.

The rocks of the Hudson-river group may be seen well developed about Catskill, on the banks of the creek and of the Hudson, and in many of the hills where the surface is not covered by the quaternary formations, from Catskill to New-Baltimore, east of the anticlinal axis. The country is very hilly and broken, except the quaternary plains, and numerous interesting facts may be observed along the banks of the Hudson and of the tributary streams between those places, wherever the strata are exposed to view.

Albany, Schenectady, Schoharie and Saratoga Counties.

The strata of the Hudson-river group in these counties may be more conveniently described under two heads;

1. Those east of the anticlinal axis, which are upturned;
2. Those west of the anticlinal axis, which are but little disturbed.

1. The anticlinal axis above referred to ranges from near New-Baltimore, by Saratoga lake to Baker's falls. The strata east of this line are upturned at high angles, and dip to the east-southeast. They may be seen well exposed in many places near Coeymans, and between that place and Albany on the bank of the Hudson, and in the beds of the streams, as Coeymans creek, Vlaman's creek, Norman's kill, and smaller streams; also in the Patroon's creek, and along the macadamized road between Albany and West-Troy; at the junction of the Mohawk and Hudson rivers; at the Cohoes falls, and various places to Visscher's ferry. These strata are rarely exposed in Albany county, except in the banks and beds of the rivers and streams, being covered in most other places by the extensive quaternary deposit that occupies so much of the surface in the counties of Albany, Schenectady and Saratoga, and which has already been described (pp. 128, 140, 148 of this volume).

At Cohoes falls, the strata are upturned at a high angle, and much contorted. Fossils are common in some of the strata of slate, but they belong to the Utica slate, the next group to be described.

At the lower aqueduct across the Mohawk at Halfmoon, the rocks are upturned at a high angle, and are exposed in the bed of the river.

Near Cohoesville, the strata are much contorted. A section near the canal, one mile and a half northwest of that village, is represented on Plate 11, fig. 1. These strata are mostly the grits (Frankfort slates).

Section half a mile west of Halfmoon landing.

		Feet.	
1	Slate.		
2	Slaty grit	4	
3	Slate	1½	
4	Compact grit	4	
5	Slate	1	
6	Compact grit	10	
7	Slate	6	
8	Grit	2	
9	Slate	1½	
10	Grit	10	
11	Slates	100	
12	Grit, light grey	6	
13	Slaty grit	50	
14	Grit, compact	4	Worked as a quarry stone.
15	Slate	3	
16	Grit, compact	4	Worked as a quarry stone.
		205	

Some of the strata thin out, and others take their places. Where derangements have occurred, it is frequently impossible to follow out all the original layers, in consequence of fracture, slipping and crushing of the strata. Some of these facts are illustrated on Plate 40, figs. 7, 8, 9, 10, and various figures on Plate 11. Fig. 10, of Plate 40, illustrates a fact of common occurrence where faults or slips are found, viz. the slate between the seams of fault is inclined at a high angle.

Figures 2, 3, 4, 5, 6, 7, 14, of Plate 11, represent contortions in the rocks of this group along the Mohawk, between Cohoes falls and the Upper aqueduct, across the anticlinal axis.*

Sections two to three miles west of Halfmoon landing.

	No. 1.	Feet.
1	Slates.	
2	Compact grit.....	1½
3	Slate	3
4	Slaty grit.....	6
5	Slate	2
6	Grit	1½
7	Slate	1½
8	Grit	1*

	No. 2.	Feet.
1	Slate.	
2	Compact grit.....	3
3	Slate	5
4	Grit	1
5	Slate	4
6	Grit	8
	This section is one quarter of a mile west of No. 1.*	

	No. 3.	Feet.
1	Compact grit.....	5
2	Slate	12
3	Compact grit.....	6
4	Slate	0¾
5	Compact grit.....	4
6	Slate.	
	This section is about one mile west of No. 2.*	

Section one and a half mile west of Rexford flats.

		Feet.
1	Grit (greywacke)	1
2	Slates	4
3	Grit	9
4	Slate	1½
5	Compact grit, five layers.....	4
6	Slates and shales	5
7	Grit	1
8	Slate	1½
9	Compact grit	5
10	Slaty grit	20
	Similar alternations very numerous.*	

Section at an oblique fault one mile west of Rexford flats.

		Feet.
1	Slate.	
2	Compact grits	1
3	Slates	4
4	Grit	1½
5	Grit, compact, two layers.....	4½
6	Grit, fissile.	50
7	Slate and grits in very numerous layers and alternations.*	

Similar rocks, with similar alternations, are continually observed in the whole valley of the Hudson, within the limits designated as occupied by this group of rocks. The same axis as that described, extends through Saratoga lake. The rocks at Snake hill, a rocky peninsula on the eastern shore, and a bluff of rocks on the southwestern shore, show the effects of the upheaving action along this axis. Illustrations may be seen on Plate 11, figs. 8, 9, 10, 11, 12, 13; and Plate 36, figs. 6, 7.

Dr. Steel described these contortions in 1824.† He says, "The country around the lake is transition, and is included in the extensive tract of transition formation which extends along

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* These contortions were examined and sketched, and the sections made by Cadet Truman Seymour, one of the assistants.

† Vide American Journal of Science, Vol. ix, p. 1, 4.

the course of the Hudson, from Baker's falls on the north, to the Highlands below Newburgh on the south. The borders of the lake are composed principally of argillaceous slate, which extends back to the more elevated ridges, where in many places it is overlaid by greywacke or greywacke slate, and in some places evidently alternates with it.

"On the eastern shore of the lake, three miles from its southern termination, there is a singular and interesting stratification of these rocks, at a place called Snake hill. This hill projects into the lake for some distance, and rises abruptly more than two hundred feet above the level of the water, presenting a naked and almost perpendicular front, which looks to the west and southwest, where the different strata are as regular and well defined as though they were painted on a wall. They rise from the water in regular succession along the southern part of this front, and pursue an elevation of from thirteen to fifteen degrees to the northwest, in straight and parallel lines, until they arrive towards the northern termination of this promontory. Here they make an abrupt curve, and pass up the mountain in an oblique direction to its summit, producing a declination exactly in an opposite direction. The curve made by the strata taking an opposite course, is the segment of a circle, the diameter of which would not exceed twenty or thirty inches. The strata are of different dimensions, varying from half an inch to two feet in thickness, and consist of alternate layers of argillaceous slate and greywacke or greywacke slate. The greywacke contains impressions of shells in great abundance; they consist principally of bivalves, and both the formations effervesce with acids.

"The Plate 36, fig. 6, is a full view of the hill with its curved strata, as they appear from the water; the back ground is the elevated ridge which separates the lake from the Hudson on the east.

"Plate 36, fig. 7, is a section of the hill, showing more distinctly the arrangement, elevation and curve of the different strata. The dark lines may be supposed to represent the *argillite*, and those of a lighter shade the *greywacke*.

"It is impossible to examine this locality, without being strongly impressed with the belief, that the position which the strata here assume could not have been effected in any other way than by a power operating from beneath upwards, and at the same time possessing a progressive force; something analogous to what takes place in the breaking up of the ice of large rivers. The continued swelling of the stream first overcomes the resistance of its frozen surface, and having elevated it to a certain extent, it is forced into a vertical position, or thrown over upon the unbroken stratum behind, by the progressive power of the current."*

The horizontal and slightly inclined strata of slates and grits of the Hudson river group, lying on the west of the anticlinal axis, as traced from New-Jersey to Saratoga lake, were *formerly* considered as *more recent strata than the upturned rocks of the Hudson valley*, and as *resting unconformably on them.* It was not until the labors of the geological survey were more than half completed, that sufficient evidence was obtained to establish the fact with *cer-*

* American Journal of Science, Vol. ix, pp. 1, 4.

tainty that they are of the *same* geological age; and not until the last year of the field duties, that my colleagues were convinced of its truth. The upturned rocks are so much modified in their characters by the causes that have deranged their position, that it requires the strongest evidence to convince one that they are no older than the horizontal rocks west of the axis of disturbance. These evidences consist in the identification of the same species of fossil remains in strata similar in character and in superposition, and in tracing the strata across the axis of disturbance. The former can be done in almost every part of the country occupied by the Champlain division in the First geological district, by means of the *graptolites*, and some other fossils in the Utica slate, and more rarely by fossils belonging to the Trenton limestone. The tracing of the strata across the line of disturbance was satisfactorily accomplished only in the valley of the Mohawk.

Localities where the order of suporposition of the strata of the Hudson-river group may be minutely examined, have already been given. Some local detailed sections of these rocks, made by Cadet Truman Seymour, one of the assistants, are subjoined.

Section at the base of the Helderberg mountain, near Salem, Albany county, at what is called the MINE.*

HELDERBERG DIVISION...	Cytherina and Tentaculite limestone.
	Water limestone.
HUDSON-RIVER GROUP....	Slate.
	Grit (calcareous).
	Slate.
	Grit (greywacke).
	Slate.
	Grit.
	Alternations of slate and grit repeated many times.

* This name of "mine" is rather complimentary than just. Some crystals and particles of iron pyrites are contained in a stratum of very impure argillo-siliceous limestone in the Water-lime group of the Helderberg division, about eight feet above its base. The stratum is about two feet thick, and geodiferous, containing calcareous spar, like that near Cobleskill and Schoharie, that yields fine crystals of calc spar and compounds of baryta and strontia. Some adepts in the use of the *mineral rod!!* have induced some credulous people to believe that gold, silver and iron, may be obtained at this place.

Section from Burton's bridge to Esperance in Schoharie county, along the bank of the Schoharie kill.

No.	Kind of rocks.	Thickness.		No.	Kind of rocks.	Thickness.	
		Feet.	Inches.			Feet.	Inches.
1	Compact grit (greywacke)			20	Grit	0	3
2	Slates and shales	2	0	21	Slates and shales	4	0
3	Greywacke and shales — four strata	4	0	22	Calciferous grit	5	0
4	Grey laminated sandstone	8	0	23	Slate	0	9
5	Slaty grit — two strata	4	0	24	Calciferous grit — three layers	16	0
6	Grit	3	0	25	Slates	4	0
7	Slates	5	0	26	Calciferous grit	5	0
8	Grit — two strata	4	0	27	Grits	4	0
9	Shales	0	4	28	Shales	1	0
10	Calciferous grit	0	6	29	Grits — two layers	0	9
11	Slates	0	5	30	Shales	0	6
12	Calciferous grit	1	8	31	Grits, slates and shales, many alternations	30	0
13	Shales	0	2				
14	Grit	0	3	32	Grits — nine layers	5	0
15	Grits and shales	1	6	33	Slates and shales	4	0
16	Calciferous grit — three strata	2	0	34	Calciferous grit	1	0
17	Slate and shale	1	0	35	Slates,	2	0
18	Grit { three layers	1	6	36	Gritty slates	6	0
	one layer	1	6	37	Grits	6	0
	one layer	3	6	38	Gritty slate	5	6
19	Slate and shale	0	3	39	Calciferous grit	4	0
						149	4

Section three-quarters of a mile northeast of Burton's bridge, Montgomery county, near the line of Schenectady county.

No.	Kind of rocks.	Thickness.		No.	Kind of rocks.	Thickness.	
		Feet.	Inches.			Feet.	Inches.
1	Shales			20	Shale	0	2
2	Slates	3	0	21	Grit — six layers	5	0
3	Calciferous grit — three layers	4	0	22	Slates	4	6
4	Slates	0	6	23	Calciferous grit	3	0
5	Grit — two layers	1	6	24	Slate	0	5
6	Shales	0	10	25	Grey grit — eight layers	7	0
7	Calciferous grit	1	0	26	Slate	0	3
8	Slates	2	0	27	Calciferous grit	2	6
9	Grit	0	3	28	Slate	6	0
10	Shales	0	4	29	Calciferous grit — two layers	2	0
11	Gritty slates	4	6	30	Slate	1	0
12	Calciferous grit	0	4	31	Calciferous grit — three layers	6	0
13	Shales	0	4	32	Shale	1	6
14	Grit — three layers	5	0	33	Grit (grey)	2	0
15	Slate	0	2	34	Shales and slates	5	6
16	Calciferous grit	3	6	35	Calciferous grit	1	6
17	Slate	0	4	36	Slates and shales	4	0
18	Shales	10	0	37	Calciferous grit — four layers	6	0
19	Grit	0	4				
						96	3

Section three-quarters of a mile northwest of Burton's bridge.

No.	Kind of rocks.	Thickness.		No.	Kind of rocks.	Thickness.	
		Feet.	Inches.			Feet.	Inches.
1	Calciferous grit — two layers.....	5	0	8	Grit	1	6
2	Shales and slates	4	0	9	Shales	3	0
3	Calciferous grit	6	6	10	Grit — six layers	6	0
4	Calciferous grit — four layers.....	6	0	11	Calciferous grit	4	0
5	Shale	0	4	12	Shales and slates.....	3	6
6	Grit	3	0	13	Calciferous grit — three layers	3	0
7	Shale	1	0	14	Calciferous grit	4	0
						50	10*

Section at Alexander's bridge, at the Upper aqueduct across the Mohawk.

No.	Kind of rocks.	Thickness.		No.	Kind of rocks.	Thickness.	
		Feet.	Inches.			Feet.	Inches.
1	Slates			7	Slate	0	4
2	Slates with thin bands of grit	30	0	8	Compact grit	1	6
3	Compact grit.....	4	0	9	Slates and shales.....	3	0
4	Grits and slates	5	0	10	Gritty slates	2	8
5	Slate	1	0	11	Compact gritty slate	3	6
6	Compact grit.....	5	0	12	Slates at the level of the Mohawk .		
						56	0

At a locality near the last section, Mr. Seymour remarks, "Here also an interesting movement has taken place. It seems that the rocks, having been bent in the form of an arch, were broken, or a rent made, through which the river flows, and then an upheave effected," as illustrated on Plate 40, figs. 4 and 5.†

The surface rocks of nearly all of Schenectady county are the grits and shales, of which sections have been given. In a few places, the black fossiliferous slates of the Utica slate, and the Trenton limestone, are exposed.

The line of the railroad between Schenectady, Ballston and Saratoga, presents some sections of the rocks of the Hudson-river group; but they do not differ from those of the preceding sections, except that the black graptolitic or Utica slate is exposed in some places.

Hudson-river group east of the Hudson.

We have thus far described some of the characters and phenomena of the Hudson-river rocks on the right bank of the Hudson, and have kept them distinct from those of the left

* The calciferous grit, and the grit in these sections, are the same rocks that have been formerly called greywacke. The calciferous grit effervesces very slightly with acids. The shales and slates are the same as the greywacke shales and slates.

† Manuscript Notes of the Survey.

bank, because they are much more deranged on the east side of the river by several fractures and lines of upheave parallel to the main axis, extending nearly north and south, and also by transverse fractures and lines of upheave, that have deranged *all the rocks of the Champlain division*, and packed them together, helter-skelter, in the utmost confusion. They are contorted, broken and wrinkled, in almost every conceivable manner, in the vicinity of the intersections of these fractures and axes of disturbance; and although the lines of bearing and of dip of the strata are nearly uniform in their *direction*, (varying from north and south to north-northeast and south-southwest for one, and from east to east-southeast for the other,) except near the intersections of the fractures and axes of disturbance, yet the repetitions of the same strata so variously, with others lying higher and lower in the geological series, and with frequent apparent inversions in the order of superposition, render it almost impossible to determine from an examination of the strata on the *east* bank of the Hudson, what the real order of superposition is. Other difficulties also present themselves, viz. the fossiliferous rocks dip to the east, and apparently plunge under those that have been considered of more ancient formation; and on the eastern flank of the Hudson valley, these plunge apparently under those that we are accustomed to consider as very ancient rocks, as gneiss, granite, mica slate, etc. Fortunately, nearly all the strata of the Champlain division are exposed in the valley of the Mohawk, unchanged in position; and in some places along the west side of the main axis, they may be examined in the order of superposition indicated in the tabular arrangement of the rocks of that division. The causes that have produced the singular position of the strata of the Champlain division east of the anticlinal axis, will be considered when the rocks of that division shall have been described.

Washington County.

The rocks of the Hudson-river group occupy a belt of country ranging from Vermont, through the townships of Hampton, Hartford, Granville, Hebron, Argyle, Salem, Kingsbury, Fort-Edward, Greenwich, Jackson, Cambridge and Easton. The rocks of this group, in the above townships, are nearly similar to those described on the west of the Hudson, but partially altered in many places by their contiguity to other rocks, so that they approach in character to the Taconic rocks, into which they seem to pass on the eastern side of the county and near Whitehall. The grits and slates form a high range of hills, almost mountains, in Cambridge, Jackson, Greenwich, Salem, Argyle, Hebron and Hartford. They are upturned at high angles, and interstratified in many places with other rocks of the Champlain division; and numerous repetitions of the same rocks, all dipping to the eastward, may be seen by crossing the line of bearing. The falls of the Batten kill near Galesville; numerous localities in its banks between Union village and Sodom; the road from Lakeville by Long pond, and thence over the mountain by Summit pond to Argyle; the road from Hebron to Argyle; from Hebron to Hartford, and from Cambridge centre to Easton, present fine opportunities for examining these strata.

Rensselaer County.

The rocks of the Hudson-river group, interstratified with other members of the Champlain division, occupy all of the county of Rensselaer, except the eastern parts of Hoosick, Petersburgh, Berlin and Stephentown, which are occupied by the Taconic rocks. The quaternary deposits conceal the rocks over a large portion of the western part of the county; but they are exposed to view in a multitude of localities along the banks of the Hudson and its tributary streams, in the hills, along the roads, and along the route of the railroad between the landing at Greenbush and the south line of Nassau. The most singular contortions are seen in many localities along the line of this railroad. They are not more numerous or remarkable than hundreds of localities that might be named, but they are on a great line of travel, and may be examined by every one who passes.

A mountain called Petersburgh mountain and West mountain, composed mostly of the rocks of this group, extends from between Stephentown and Nassau, through Berlin, the east part of Grafton, and west parts of Petersburgh and Hoosick.

The general strike of the rocks is about N. 20° E., and the dip at various angles from twenty to eighty degrees to the east-southeast. About one and a half miles from Greenbush on the road to Sandlake, the rocks dip in opposite directions in the same hill, the strike being nearly in the usual direction.

Red and green slates are interstratified with the rocks of this group, and with the coarse grey and greenish grit that is supposed to be equivalent to the Shawangunk grit. It is called by Prof. Eaton, "Millstone grit, and grey rubble."*

No fossils have been observed in the rocks of this group in Rensselaer county; and the prevailing rocks are slates, slaty grits and coarse grits, often very much indurated, and injected with veins and nests of milky quartz, and sometimes with carbonate of lime.

Local details. It is unnecessary to specify many localities, where the rocks under consideration are visible in almost every mile along every road, stream, hill and valley, and where the dip and strike are without any great variations. Slaty grits, very much contorted, occur in Troy near the Catholic church. The slates, some of which belong to the Utica slate, occur in the banks of the Poestenkill, and in the hill on the east side of the city. The grey grits and slaty grits are quarried for building stone, on the hill east of Troy, and near Lansingburgh. At one of the quarries (Wickwire's), the strata, composed of slaty grit and shale, are bent and distorted as represented in Plate 10, fig. 12. West mountain is mostly grit, and slaty grit and shale, and the latter is called by the inhabitants *bastard slate*. For ten or twelve miles in length, on the summit of the mountain, the rock is so near the surface over a breadth of one or two miles, that cellars and wells can rarely be dug without blasting. The water is supplied by springs, which are abundant. The red slate is found on the east and west sides of the mountain, and in some places alternates two or three times; and this and the coarse

* Eaton's Geological Text Book, 2d edition, p. 73.

grit with which it is frequently associated, are supposed to belong to the group described in the Ontario division.

Prof. Dewey described the principal rock of this group so correctly in his "Section from Taconic range in Williamstown, to the city of Troy on the Hudson," in 1821, that his description is quoted below.

"*Greywacke.* This rock begins to appear about sixteen miles east of Troy, covering the surface in rounded masses of very various size, and forming also vast strata rising into hills in Petersburgh, constituting the mountains of Grafton, and extending as the general rock through Brunswick to Troy. The mountains of it in Grafton are, I judge, from eight hundred to twelve hundred feet in height. It is, like all the other strata from Hoosick mountain to the Hudson, inclined to the east at various angles from ten to forty degrees; its general inclination may be twenty to twenty-five degrees. It consists of quartz, cemented by a greenish argillaceous substance, which generally forms the principal part of the rock, and is evidently a mechanical deposit. The quartz is sometimes very fine, but generally is readily seen by the eye, and is occasionally so large and abundant that it resembles breccia. The fracture often shows the quartz to have been rounded masses, and in these cases the stone does not appear porphyritic. In other cases the stone is so very close-grained and compact, containing also felspar, that it might have passed for porphyry, had it not been connected with specimens that could not be mistaken. This rock, though quite tough in the cross fracture, readily breaks into prismatic fragments along its veins, which are usually filled with quartz. By the action of the weather, large rocks are divided into innumerable prismatic bodies. A small stream which rises in the mountains in the east part of Grafton, and runs westward into the Hudson below Troy, affords an excellent opportunity for examining the position of the rock in numerous places. Occasionally there appear in this rock, beds or veins of a reddish argillaceous slate, in Grafton and Brunswick."

"Near Troy the greywacke has a much finer texture and darker color, and some of it takes a fine polish.* Where the greywacke stops near Troy, there begins a bed or stratum of argillaceous slate."†

The line of the graded road leading from Troy through Hoosick four corners to Bennington, offers fine opportunities for examining the strata of some of the rocks of the Champlain division.

The mouth of the Hoosick also may be mentioned as a locality worth visiting by those who may wish to examine the rocks,‡ and also the side of the turnpike half a mile west of Nassau village.‡

Prof. Eaton, in his description of the greywacke of Rensselaer county, says,‡ "This coarse grey rock forms the basis of more than half the county. It is perfectly insulated, and lies upon the argillite like a huge turtle upon the beach; its back forming the middle and elevated

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* Vide Eaton's Geology.

† American Journal of Science, Vol. ii, p. 247, 248; and vide also Idem, Vol. viii, p. 21 and 24.

‡ Geological and Agricultural Survey of Rensselaer County, 1822, p. 20, 21.

part of the county. Although the same rock forms the basis of a large part of the adjoining counties on the north, south and west, it does not extend unbroken into either of them." "On the east side, it terminates abruptly below the brow of the hill (mountain) which bounds the valley of the Little Hoosick on the west.*" "Wherever the greywacke rests immediately on the argillite, it is the slaty variety, and takes on the form and position of the argillite."* "Though greywacke slate is generally of a grey color, it is found of a sky blue color in many places, and sometimes brick red. There is a limited locality of the latter color on the line between Troy and Brunswick, on the Sandlake road. On ascending the hills, we find the fissile slaty varieties of greywacke giving place to the more compact, and the color becomes more blue and greenish." "Farther east, in the interior of the county, as in Grafton and Sandlake, we find the beautiful green and blue varieties very abundant; but on ascending the higher hills of those towns, the only rock in place that presents itself, is the coarse rubblestone variety of greywacke." "This rock has formed a subject of some discussion. It puts on so many appearances, that it has been a source of much confusion when studied in the state of hand specimens. There are numerous localities in the towns of Grafton and Sandlake, where this rock in a single, continuous, unbroken field, presents the green greywacke, the coarse granulated variety, the porphyritic variety which is speckled with felspar, and that variety which has the appearance of puddingstone. I have examined vast rocks of the compact, blue, and green greywacke, which embraced within their most solid parts large masses of an aggregate in all respects resembling the common puddingstone."*

It might be inferred from the above quotations, that the coarse greenish grit rock and conglomerate, which sometimes approaches in character to porphyry and greenstone, was superimposed on the slate rocks *unconformably*. It *may* be so situated, but I have seen no evidences that would lead to that conclusion.

The slate rocks of the Hudson-river group in Rensselaer county, and in fact in all the counties underlaid by the upturned rocks of the Champlain division, are very difficult to distinguish from those of the Utica slate (or black slate), except where the latter contains fossil remains (graptolites), or thin layers of limestone. The upper layers of the slate of the Hudson-river group also contain graptolites, some of the species of which are different from those of the Utica slate. In consequence of the difficulty of distinguishing these two masses where they and the included mass of interstratified grits and slates are broken up and confused in their stratification, I have barely mentioned the slate; but it ranges along the banks of the Hudson, from Fort-Edward by Troy, Greenbush to Castleton, and still farther south, and is frequently seen interstratified with the Utica slate and its thin bands of limestone.

* Geological and Agricultural Survey of Rensselaer County, 1822, p. 22, 21.

Columbia and Dutchess Counties.

The rocks of the Hudson-river group, and of nearly all the Champlain division, are remarkably well developed in these counties. They are well exposed to view, and capable of rigid examination and identification in the bed and banks of Kinderhook creek, from Valatie to its mouth; the banks of the Hudson, near the city of Hudson; at the base and on Merino mountain, to the southwest of Hudson; the rocky island called Rogers's island, between Hudson and Catskill; the rocky shore of the Hudson river, from the mouth of Ancram creek to Redhook; the rocky islands below Redhook landing, and from Redhook landing to Barnegate. The rocky shore of the Hudson above mentioned, offers better opportunities for a rigid examination of the rocks of the Hudson-river group, with their derangements, contortions, wrinklings, faults, and cleavage planes, than any equal portion of the country I have examined; and I would recommend to those who wish to study the rocks of this group, and their derangements, to take a row boat, and examine this shore attentively. It will amply repay every one who takes any interest in practical and physical geology.

A few of the phenomena alluded to above, are partially illustrated by the diagrams on Plate 9, figs. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 20, 21; Plate 10, figs. 2, 3, 6, 7, 8, 9, 10, 11; Plate 24, figs. 1, 2, 3; Plate 29, figs. 1, 2; and Plate 38, figs. 1, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12.*

The country back from the Hudson also presents very fine opportunities for studying these strata wherever they are uncovered. They consist of slaty and thick-bedded hard tough grits, shale and slate, the latter often changed to siliceous slate and basanite, in the vicinity of quartz and other intrusive veins. These rocks range through the western half of Columbia county, and the townships of Redhook, Milan, Rhinebeck, Clinton, Hydepark, Pleasant-valley, Poughkeepsie, Lagrange, and the northwest part of Fishkill in Dutchess county.

Most of the grits are calciferous, so as to effervesce slightly with a strong acid, when taken from a sound rock that has not been exposed to weathering. The grits, shales and slates are interstratified, alternating a great number of times, like those on the Mohawk river and Schoharie kill. They are mostly composed of fragments of the lower rocks of the Champlain division.

The coarse greenish grit that occupies so prominent a place in Rensselaer county, is also an important rock in Columbia county, but is not so coarse-grained, and becomes finer farther south. It forms a mountain mass, extending from the northwest corner of New-Lebanon, through the east part of Chatham, west part of Canaan, Austerlitz, west part of Hillsdale, Taghkanic and Gallatin in Columbia county; and Milan, Redhook, Rhinebeck, Clinton and Hydepark in Dutchess county.

Veins of quartz abound in this rock, and in the northern part of Columbia county. The

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* I spent a considerable time in meandering and examining the shores of the Hudson, encamping every night wherever the darkness overtook me. Most of the notes of the sections and observations made were accidentally lost (blown away in a gale of wind).

whole rock in some localities seems to be permeated by them, and the rock has an aspect almost trappean.

Veins of quartz traverse all the rocks of the Hudson-river group more or less abundantly, but more frequently it is only the proper *joints* of the rocks that are filled with quartz and calcareous spar.

Local details in Columbia and Dutchess counties. Rocks that have formerly been called greywacke, varying in texture from an argillaceous slate to a sandstone, succeed the limestone of the Fishkill valley about three-quarters of a mile from the village of Fishkill, on the old post-road from New-York to Albany. It seems to pitch under the limestone, though the contact was not seen. The dip is generally to the east-southeast from ten to fifteen degrees, but at Wappinger's creek it is nearly vertical. Some quarries of the grit rock have been opened along the road, for wall stone. It is easily quarried into rhombic blocks and fragments, in consequence of the joints that traverse the rock.

The grit and slate rocks of the Hudson-river group are seen abundantly in place, three miles south of Poughkeepsie, on the post-road, and continue to be seen at intervals, emerging in ridges and hillocks through the quaternary formation of the Hudson valley, to Hyde-park, Rhinebeck, Redhook, Clermont, Johnsville and Kinderhook. They are frequently interstratified with the slates, and sometimes with limestones and other rocks that will be subsequently mentioned under the heads of Utica slate, Trenton limestone, Calciferous rocks, and Potsdam sandstone. The strata dip at various angles from eight to ninety degrees, generally to the east-southeast, but in some places to the northeast, and even to the north. The latter directions of the dip are local variations, due in most, if not in all cases, to derangements of the strata along transverse axes of disturbance. The rocks are traversed by veins of quartz and calcareous spar.

Between Lower Redhook village and the landing, the grit rocks of the Hudson-river group were exposed to view, where in many places they emerged from the quaternary; and in two places on the road, about three-quarters and one mile from the village, where the rock had been recently uncovered in making the road, well characterized drift scratches were observed. The surface was smoothed off as if ground down by attrition, and showed no inequalities but those of the scratches. The dip in all the localities was eastwardly at a high angle.

Singular contortions of the grit and slate rocks may be seen on the shore a few rods below the landing. The rocks are bent, and folded, and packed together in such a way as cannot be easily described or represented. The strata are nearly vertical, and bent into regular and irregular curves and folds. The grit rocks, in strata from six to twelve inches in thickness, are interstratified with slaty grits and slate. The diagram, Plate 10, fig. 11, which is an imperfect horizontal section, will give some idea of the arrangement of the strata. Between the warehouse and these contorted rocks, the grit rock is seen nearly vertical, immediately overlaid by nearly horizontal slate. The strata are very beautifully exposed to view between Redhook and Rhinebeck landings on the shore of the Hudson, and on the small rocky islands near the east shore. Smoothed and scratched surfaces may be seen where the rocks have

recently been uncovered of the overlying clay, by excavating roads, or the action of water. One locality was observed about two miles south of Redhook landing, where two distinct sets of scratches were engraved on the rock, with directions of S. 10° W. and S. 20° W.*

The smoothed or scratched grit or greywacke was seen between Rhinebeck landing and village, west of the ridge of naked grit rock that paves the road west of the creek; also at several places on the Rhinebeck and Pineplains turnpike road; also two and three-quarter miles from Lower Redhook village on the road to Long pond.

A quarry of flagging stone, and for building stone, has been opened near Lower Redhook village (about half a mile east), in the slaty grits of the Hudson-river group. The stone is easily quarried in slabs of five to fifty square feet, and three to eight inches thick.

A broken rocky ridge of grit and slaty grit interstratified with slate, extends from near Rhinebeck, by Hydepark, to near Poughkeepsie. It is on the east of the old post-road, but the strata are exposed in many places along the road. The dip of the rocks is eastwardly, generally east-southeast, at very variable angles from forty to ninety degrees. At Lewisville opposite Lewis's landing, the strata are vertical.

The smoothed and scratched greywacke or grit was observed on the ridge east of Hydepark; and about half a mile east of the post-road opposite to half a mile north of De Graff's tavern, the grooves and scratches, which were perfectly similar in size, depth and direction, were interrupted by slips or slight faults of the rock since the scratches have been made. Prof. Cassels observed them in several places in that vicinity. The edges of the rock, both above and below, on the slip, were sharp, and the grooves and scratches of the lower mass were continuous plump up to the surface of the upper mass; and on the upper, mass they were continued quite to the sharp edge along which the slip has taken place. Similar facts have already been stated in the article on the drift deposits, as occurring in slate between Copake and Boston corners, and in several localities about one mile west of Long pond in Clinton, Dutchess county.

Flagging stones are quarried from the slaty grits about a mile east of the red school-house in Hydepark.

The rocks are well exposed between Hydepark village and landing, and along the shore from the landing some distance to the north. The grit, composed of distinct particles of slate in addition to the usual materials, is interstratified with a fissile slate, almost like roofing slate, a little above the landing on the shore. The rocks are also traversed by numerous veins of calcareous spar, and by some of quartz. The long narrow island and several smaller ones between Hydepark and Lewis's landing, offer fine exposures of the grits and slaty grits of the Hudson-river group.

We will now trace the shore from Hudson to Barnegate and Fishkill. Rogers's island is situated between Hudson and Catskill. Most of it is alluvial, and frequently overflowed by the tides; but the southwest part of the island is composed of rocks of the Hudson-river group, rising ten to forty feet above the tide level.

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* They have been more particularly described under the head of Drift deposits, Diluvial scratches or Drift scratches.

The rocks, consisting of grits, slaty grits, gritty slates, and slates, dip to the east-southeast from fifty to ninety degrees. An example of contortion, represented on Plate 24, fig. 1, may be seen on this island about forty or forty-five rods south of the north end of the rocky portion.

Contorted rocks are seen in place a little below Oak hill and Catskill ferry. They contain basanite, and rocks continue in place to Croft's point (Vide Plate 29, fig. 1).*

At the point one and a half miles below Croft's point, the rocks are much contorted, as represented on Plate 9, figs. 1 and 2; and a short distance below the wharf, a fault may be seen, as represented Pl. 9, fig. 12. A short distance below this point in Clermont, the strata are vertical, composed of alternating strata of grit or greywacke and slate. The *divisional planes of the slate make an angle with the strata*, as represented on Pl. 10, fig. 7. The dotted strata are the grit rocks, from a few inches to three or four feet thick, and the shaded strata have their laminæ of cleavage in the position of the lines of shading. This locality is on a small point; and in the next bend of the shore below, is an example of zigzag contortion, as represented on Pl. 9, fig. 3. At the point below, where the north line of Germantown intersects the shore, veins of calcareous spar intersect the strata of grit and slate. The dip is here very variable. Another example of zigzag contortion, as represented on Pl. 9, fig. 4, may be seen about opposite to the north end of the Ooze island, where contortion is indicated on Pl. 29, fig. 1.

Nearly opposite the light-house below Bristol, on the eastern shore, two examples of contortion may be observed, as represented on Pl. 9, figs. 6, 7. The rocks are alternations of grits and slates, as represented on those figures. The localities are about a quarter of a mile from each other, and equidistant from a point opposite to the light-house, and are represented on Pl. 29, fig. 1, at x and y.

Below Barrytown or Upper Redhook landing, are two long, narrow rocky islands called Magdalen islands. The strata on them are well exposed to view, dipping as usual to the east-southeast, or more nearly east, at high angles. These islands are on a line with the shore above Barrytown, and are probably a continuation of the same line of elevation, and are composed of the same kinds of rock.

About one mile below Rhinebeck landing, thick layers of grit are interstratified with slate, and bent nearly as represented on Pl. 10, fig. 9.† A few rods farther south on the shore, the slate has its *cleavage* nearly *vertical;* while the *dip of the strata, both of the grit and slate, is about sixty degrees to the east* (Vide Pl. 10, fig. 8). At a distance of thirty or forty rods still farther south, the rocks are bent in opposite directions, as represented Pl. 9, fig. 8, and Pl. 10, fig. 9.

The arched, bent and contorted strata of grits, slaty grits and slates, may be seen to great advantage from one to three miles below Rhinebeck landing, by going near the shore in a small boat.

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* The word *tertiary*, after clay hills, should read *quaternary*. Figures 1 and 2 illustrate also the alluvial flats, both the marshes and those covered by the tide.

† The lines of shading on the slate do not represent the true directions of the lamination. A few rods above this locality, nodules of argillaceous iron ore were observed imbedded in the slate.

The rocks are contorted on the point just below Rhinebeck landing (Vide Plate 9, fig. 9; and Pl. 29, fig. 2).

The shore above Thompson's landing, three or three and a half miles below Rhinebeck landing, is a high bluff with an abrupt escarpment of contorted rocks.

About forty rods northeast of Gen. Lewis's landing, on the shore of the small bay, is a remarkable instance of *contorted strata, but with parallel, plane, slaty cleavages.* Plate 10, fig. 6, illustrates the stratification and slaty cleavage, and Pl. 29, fig. 2, the position on the shore, of the above locality, which can be examined at any stage of the tide, by going in a small boat. The grits, slate and shale, can be examined all along the shore for a mile below this landing; and about a quarter of a mile below, the strata are very distinctly arched.

Contortions of all kinds may be seen in the grits and slates along the shores of this part of the Hudson; and a *local change of direction of the line of bearing of the strata in the vicinity was observed to be a constant accompaniment of the contortions,* so that by observing one, I was sure to find the other. These contortions and changes of strike, seem, from the observations made, to be connected with the transverse axes of disturbance.

Another example of *contorted strata, with plane laminæ of cleavage,* may be seen on a rocky point about three and a half miles above Hydepark, about one mile above the rocky island. It is represented on Pl. 10, fig. 10.

Another example *of the same remarkable fact,* is about two and a quarter to two and a half miles below Hydepark, just below the mouth of a small creek. This locality is well worth a visit by those who doubt about the conformity of strata and slaty cleavage, and those who still adhere to the views that were advocated a few years ago by Mr. Bakewell* and others, who thought that observation justified the conclusion that the slaty cleavage and strata planes made constant angles of sixty and one hundred and twenty degrees. Figures 3,† 4 and 5‡ of Plate 10, are additional examples of the same facts; and figures 3, 4, 5, 6, 7, 8, 9, 10 of Plate 10, show that these planes make all possible angles with each other.§

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* Vide Bakewell's Elements of Geology.

† Mr. Briggs observed the slaty cleavage distinct from the stratification in the slate rocks, in making his section of the rocks from Poughkeepsie to Sharon in Connecticut, about a mile from Pleasant-valley (Vide Pl. 10, fig. 3).

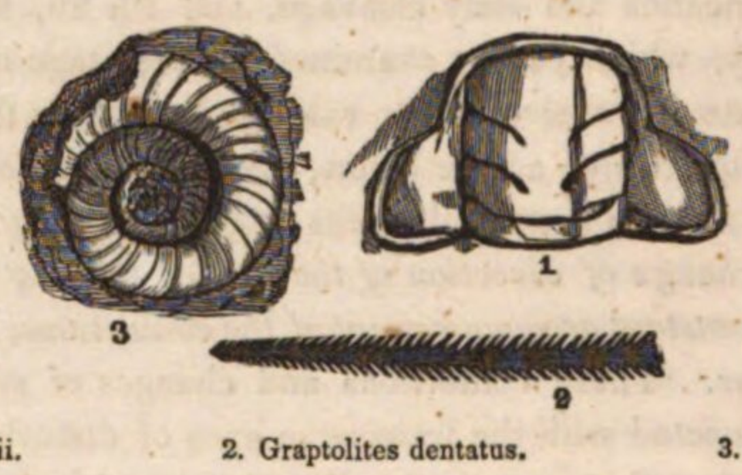
‡ The locality of fig. 5 is a little west of Jackson corners, on the road from Pineplains to Clermont. The strata planes dip to a point a little north of east about fifteen degrees, while the slaty laminæ dip sixty to seventy degrees to the south of east. The same fact was observed in several places on the road farther to the west.

§ The observations on slaty cleavage above referred to, and illustrated by the diagrams, Pl. 10, fig. 3, 4, 5, 6, 7, 8, 9, 10, were made in the summers of 1836 and 1837; and a slight notice, indicating the conclusion that was to be drawn from them, was published in the Second Annual Geological Report of New-York, page 161. Similar observations have been made in England and Wales, by Prof. Sedgwick (Vide Lyell's Elements of Geology, 1st American edition, from the 1st London edition, 1839, p. 139; Prof. Phillips's Treatise on Geology, London, 1837 and 1839; Geological Transactions, vol. iii, New Series).

2. Utica Slate.

Synonims. *Mohawk slate*, *Black slate and shale*, *Fairfield slate*, *Graptolitic slate*, of the Geological Reports of New-York; *Transition argillite*, *Wacke slate*, and *Glazed slate*, of Prof. Eaton's works. No. 3 of the Pennsylvania Survey.

Fig. 24.



1. Triarthus beckii. 2. Graptolites dentatus. 3. Trocholithus ——.

The rocks of this group consist of dark colored argillaceous slates of several varieties, in different parts of the First geological district. In the valley of the Mohawk above Schenectady, in Saratoga county, west of the main anticlinal axis, and between Fort-Ann and Glensfalls, it is scarcely disturbed from the position in which it was originally deposited; and there it shows its unaltered characters of a dark colored slate, frequently loaded with carbon, and containing various genera and species of vegetable and testaceous fossils. It is interstratified with thin bands of limestone, and sometimes also with thin layers of carbonate of iron as subordinate strata, and it passes into the Trenton limestone by gradual interstratification. Thin bands of slate are interstratified in the limestone, and thin strata of limestone in the lower part of the slate containing fossil remains. The *Triarthus beckii*, and several other fossils, were found in one of these bands of limestone. The slate in mass, in its lower portion, is calcareous.

On the east side of the main anticlinal axis, the strata of this group are generally similar, and contain the same fossil remains, but differ by frequently presenting the slaty cleavage distinct from strata planes or planes of deposition; by being upturned at every angle to the horizon, crushed, shivered, and contorted in the most extraordinary manner; and by being frequently altered in texture by causes that have produced the above mentioned effects. The *glazed slate* of Prof. Eaton is a variety of this slate, in which the small fragments into which it breaks in consequence of its having been shivered, are coated with a black glazing, having the appearance in some localities of a thin film of anthracite. Another modification of this slate, which is quite common on the east side of the Hudson, and is not uncommon on the west bank east of the anticlinal axis, is *siliceous slate*, varying in character from basanite to common siliceous and flinty slate. It is red, green, brown, black, and of various intermediate shades of color.

These slate rocks form a large proportion of the slate of the Hudson valley. They may generally be distinguished by their dark and black color; but there are some strata among the *grits* of the Hudson-river group, that can scarcely be distinguished from these. They range through the State from Vermont to New-Jersey, and in fact from Canada across Virginia. They are well exhibited to view on the banks of the Hudson above Newburgh, and at Fishkill landing, Blue point, Marlborough, Poughkeepsie, Hudson, Troy, Baker's falls, and many places along the shores to Lansingburgh; on the Mohawk, at Cohoes falls and below; on the railroad from Schenectady to Ballston; also in the village of Ballston-spa; in Kingsbury, Washington county, between Sandyhill and Fort-Ann.

Search for Coal in the Utica slate group.

The slate of this group is often black, highly carbonaceous, glazed with anthracite, and contains thin seams and small fragments of this combustible. Too many adopt the plausible idea, that if a little of the mineral which is sought, be found on or near the surface, extensive beds must necessarily be found below.

Some of the localities where excavations for coal have been made, are well calculated to deceive those who are not professional geologists and mineralogists. In some of them, small layers and lumps of anthracite are actually seen; in others, the rock breaks into irregular fragments which are invested with a film of this combustible, and the fragments present an aspect somewhat similar to the carbonaceous matter near the outcropping edges of beds of anthracite. In some localities vegetable remains are found, and the slate is glazed with films of brilliant anthracite. There are, at least, five species of fucoids, among which Mr. Conrad recognized the *Fucoides dentatus* and *Fucoides serra*. One species of trilobite, which will be described, was also found in the fissile slate.

About one mile south of Hudson, an excavation has been made for coal. Some of the rocks might be mistaken for coal, by those who are not minutely acquainted with coal and its varied aspects. The slate is highly impregnated with carbon, the fissures being filled with thin films of anthracite, and small pieces of this combustible of the size of a pea are not uncommon. This slate strongly resembles the impure anthracite and anthracitic shales of some of our coal mines. Graptolites are abundant and very beautiful at this locality.

At Rider's mills in Chatham, Columbia county, both the slate and limestone are glazed with anthracite; and these materials having been excavated from a mill-race, induced high expectations of the value of the coal mine that was believed to lie below, and which was supposed to be bituminous coal. Mr. Rider was offered a large sum for his farm, which he refused in consequence of the supposed value of the mine.

Two excavations have been made for coal, near the line between Canaan and Austerlitz: one on the farm of Elisha Lord, in Austerlitz; the other on Joseph Olmstead's land, in Canaan. At one of these places, a company in New-York expended eleven hundred dollars. They bored about one hundred feet, and in that depth passed through five inches of carbonaceous or plumbaginous slate. The rocks of these hills are talcose and chloritic slates.

On the east bank of the Hudson river, two and a half miles below Poughkeepsie, an excavation has been made in the slate rock for coal. A quartz vein intersects the slate, and in this, pieces of anthracite of the size of a pea are found. This vein has been followed down many feet, with the expectation of finding this combustible. It is scarcely necessary to remark, that masses of workable coal have never yet been discovered *in veins traversing the strata.*

At another locality, near Poughkeepsie, a well has been bored two hundred feet in search of coal. Excavations have been made in ten or twelve places in the vicinity of Poughkeepsie, and from five thousand to six thousand dollars have been expended in search of this combustible. Many believe that coal exists at a considerable depth. A large piece of anthracite is said to have been found at the mouth of Wappinger's creek, about fifty years ago. This fact, the black color of the slate in many places, and the films of anthracite which frequently glaze its surfaces, have nourished the hopes of those who ardently wished that coal might be found there.

In Fishkill, on the farm of Mr. Annan, is an excavation which has been made in expectation that coal would be found. It is in black slate, glazed with anthracite, and would be more likely to deceive those who are not familiar with coal regions, than any I have seen, except those of Hudson, and Rider's mill in Chatham. This place has been called the *Coal mine*, for a century. It is at the base of the Highlands, and very near the junction of the granitic and slate rocks.

Dr. Horton, speaking of these rocks in Orange county, says, "In very many places in the county, this rock is loaded with carbon, so much so as to deceive the inexperienced eye into the belief that it is coal; hence the very common belief among us, that coal in abundance will yet be found in the county. Mining for coal, in a small way, has been undertaken in several places, and the rock has been penetrated, by boring for this purpose, more than two hundred feet. These undertakings have all resulted in loss, and, in a few cases, to a ruinous extent. They tend, however, to reveal the true character of the rock, and to show us how small a probability exists of discovering extensive beds of coal in this formation."*

Excavations have been made for coal in several places in Ulster county, the principal of which are,

1. That on the bank of the Hudson, at the Blue rock in Marlborough.
2. That a few miles west from the Hudson, on the Marlborough mountain.
3. That at the base of the Shawangunk, near the Coxenclove creek in Marbletown, a little north of the road from Springtown over the mountain to Highfalls. This excavation was made in 1836, in the black glazed slate with thin scales of anthracite or carbonaceous matter. Pyrites occur also in thin scales between the laminæ of the slate, and frequently they are plumose, and arranged around a centre something like the petals of a flower. They make beautiful specimens.
4. In New-Paltz.
5. In Plattekill.

* Third Annual Geological Report of New-York, p. 143.

Some have also been made in Greene county, near the Hudson. One was made on the shore of the Hudson between Athens and Coxsackie, about a mile above the light-house. The rock here, as in many other places where excavations in search of coal have been made, is black and more or less loaded with carbon, glazed with thin films of anthracite, and sometimes exhibits small pieces of that combustible. This excavation, which was made at high-water mark in 1836, has since been filled by the washing in of pebbles and shingle by the waves on the beach.

Excavations have also been made in search of coal, in Albany, Saratoga, Washington and Rensselaer counties, in the same black slate.

Many localities might be mentioned, but the preceding are sufficient to indicate the general character of the coal mines which are so often described in our newspapers as important discoveries, by the fortunate finders, or by speculators.*

Fossils of the Utica Slate.

These are mostly plants (graptolites), of which there are at least five species. One species is serrated on one side; another on both sides like the teeth of a saw. One species is serrated, with a long and extremely delicate awnlike appendage, extending from the smaller extremity of the serrated leaf, and one of them is branched. Mr. Conrad recognized two species as the *Fucoides serra* and *F. dentatus*. Two other species slightly resemble *F. lineatus* and *F. ramulosus*.

The principal localities where the graptolites or fucoids have been observed in the First geological district, are,

1. At Ballston-Spa, where they are extremely abundant. The bed of the small stream near Mr. Taylor's residence is paved with this rock, replete with one or two species of the graptolites. They are not as distinct and beautiful as at some other localities, but they are at a place of much resort, and on a great line of travel, where many will examine them. The slate also shows the *joints* that traverse the rocks in two or more directions. The strata are here nearly horizontal.
2. The shore of Saratoga lake, near Snake hill. The fossils obtained from this place are not distinct and well characterized as they are from many other places, perhaps because they were from masses that had been exposed to the weather.

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* I feel it my duty here to expose the conduct of an individual named ADSETT, who travelled over a part of Columbia county, pretending that he was one of the geologists employed by the State. In repeated instances, it is stated, he has taken leases of land, and then pretending to have discovered some valuable mines, sold out the leases. He has thus swindled persons of various sums, amounting in the aggregate to some hundreds of dollars at least. He is believed to be the same man who induced the company in New-York to bore and dig for coal in Canaan and Austerlitz. Some similar circumstances have been made known in Ulster county, in relation to lead and other mines. It is not known whether the same individual was concerned in these.

3. The banks of the Norman's kill, one and a half or two miles from Albany, below the bridge on the road to Schoharie. They are here extremely abundant, and well defined.
4. Baker's falls, a little below Sandyhill. Baker's falls is a locality worth visiting by every geologist. Here a thickness of thirty feet or more of the slate rock is so filled with these impressions, that the thinnest layer can scarcely be split off, without exposing a surface almost covered with them. Bands of iron ore (carbonate of iron), and veins of crystalline carbonate of lime, may be seen in the same rock. The best locality for examining these fossils is just below the falls, perhaps one hundred yards below the mill on the left bank. The rock that is weathered, shows them very indistinctly, but the sound unaltered rock yields beautiful specimens.

   At a little distance below the ferry on the Saratoga shore, at and near the sawmill, the junction of the slate and Trenton limestone, and the graduation of one into the other by interstratification, with their numerous and beautiful fossils, which are intermingled near their junction, can easily be examined when the river is low. The trilobite, the *Nuttainia concentrica* of Eaton, is extremely abundant; and on one specimen of a thin band of limestone six inches square, from the slate, were no less than ten of these trilobites, some of which were entire, and one of the *Triarthus beckii*.

   At the falls, opposite the locality already described on the left bank, the graptolites are as abundant as on the other side of the Hudson; but the strata on the left bank are upturned, and dip at a high angle to the east, while the strata on the right bank are nearly horizontal.
5. On the shore of the Hudson in the northwest corner of Stuyvesant, Columbia county, beautiful specimens of graptolites were obtained from the black slate, a little distance above the brick-kilns. Two strata of the black slate, three or four feet thick, separated by a stratum of slate, are filled with them.
6. They occur also at Hudson, in the slate rocks below the Pavilion, between the steamboat landing and the point at the north end of the town.
7. The most beautiful and brilliant specimens were found at what is called the *Coal mine*, about one and a half miles south of Hudson, in the black slate. The fossils here are so brilliant as to be almost specular, are perfectly defined in the most minute markings, and are composed of a thin film of anthracite.
8. These fossils are also seen in the slate rocks at the lower falls of the Kinderhook creek, and a small trilobite was also found at this place in the slate.
9. They were seen also abundantly in the black slate of the Shawangunk mountain, about one and a half miles east of Ellenville, on the sides of the road over the mountain, where rock excavations had been made at the height of five hundred to seven hundred feet above the valley.
10. They occur also at Blue rock in Marlborough, on the bank of the Hudson.

Many other localities might be named, but the above are sufficient to illustrate the various species found. They will be figured and described in the Palæontological Report.

The graptolites have been mentioned as extremely abundant. Testacea and crustacea are rare in most places observed in the First geological district, but at some localities they are common. The following localities show these fossils:

1. Near the sawmill on the Saratoga shore of the Hudson, below the ferry from Sandyhill, and above Baker's falls.
2. Cohoes falls and the vicinity, where two species of trilobites and several of small bivalve shells occur.
3. The bed and banks of the Champlain canal, between Waterford and the Mohawk river.

Some fossils have been found in other places in this slate, as at the north end of Troy, in River-street and Mount Olympus, where orthoceratites were found;* the banks of Saratoga lake, near Snake hill; the rocky bluff bank of the Hudson, at the city of Hudson;* and the banks of Kinderhook creek, between Columbiaville and Kinderhook at the lower falls.

Among the fossils found at these various localities, are,

Trilobites	at least	3	species.
Orthoceratites	"	2	"
Trocholite	"	1	"
Bivalves	"	3	"
Crinoideal vertebral spines.....		2	"

"*Flinty slate.*"† Siliceous slate is quite common as a modified form of the rocks of the Hudson-river group, and it ought perhaps to be described among the metamorphic and altered rocks. It occurs in very numerous local patches and narrow ridges in the Hudson valley, and mostly near the Hudson river, between Sandyhill and Marlborough, and it is also found in Orange county. It may be seen at the following localities:

1. About two and one-half miles south-southwest of Hudson, in the bed of a small stream. This is to the west of the Highland turnpike, and after crossing the brecciated limestone, the slate is again observed, which is highly siliceous, passing through all the shades of difference from common siliceous slate to basanite and hornstone.
2. About one and a half miles southwest of Clermont. The slate passes through all gradations from fine argillaceous slate to basanite. Some of it would answer for hones; and I have used a piece of the rock, of a suitable degree of hardness, for setting a fine edge on a razor and a penknife.
3. Several localities in Germantown. Flinty and siliceous slate were seen in ridges not far to the west of the Lutheran church in Germantown; and also on the road from that church to a point on the post-road, one mile south of Clermont, Columbia county.

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* Vide Eaton's Geological Text-Book, 2d edition, Note, p. 72; and Geological and Agricultural Survey of the vicinity of the Erie Canal, p. 67.

† Eaton's Geological and Agricultural Report of Erie Canal, p. 69.

4. About three and a quarter miles northwest of Lower Redhook, on the road, on or near the land of Nathan Beckwith, is a ridge of black siliceous slate. Copper pyrites was rather abundantly disseminated in some of the loose masses of this slate. The same kind of black siliceous slate was seen in place on the next swell of land to the west. Several places where siliceous slate occurs, were seen between Lower Redhook and Clermont.
5. "Opposite to Troy, it is exhibited in a very perfect bed;"* and below Troy, on the shore, beds of siliceous slate occur.*
6. "It forms most of the bank of the Hudson river at and below the city of Hudson, passing into beautiful lydian stone in some places."*
7. The green jaspery slate is common, but not in large beds or masses so far as observed, except one, which is three or four miles south of Albany, described by Profs. Eaton and T. R. Beck, in the Geological and Agricultural Survey of Albany County.

   The flinty or siliceous slate assumes almost every variety of aspect, from common siliceous slate, through basanite or touchstone to hornstone and petrosilex.
8. At Blue hill, about four miles south-southwest of Hudson. The slate varies from fissile to compact, and in some places is changed into basanite, petrosilex, and hard compact siliceous slate; and in color, is black, blue, red and green. The strike of the rocks is somewhat variable, but is generally about S. 30° W.
9. In Chatham, one and three-quarter miles from Malden, on the road to Valatie, a ridge of compact siliceous slate was seen in the meadow on the east side of the road. Red jaspery slate was seen abundantly in loose masses near the same place, but not *in situ*.
10. In Chatham, above Rider's mills, near the road to New-Lebanon, and near the north line of Columbia county, red jaspery slate was observed in place. Several localities of siliceous slate were observed along the Kinderhook creek, on its left bank, between Rider's mills and Valatie. Siliceous slate and red jaspery slate were also seen in Granville, Washington county, between Granville and West-Poultney.

Many more might be mentioned, but it is unnecessary to multiply localities. They are generally situated on or near the transverse axes of disturbance, and at or near the intersections of these northwest and southeast axes with the principal north-northeast and south-southwest axes of fracture and upheave.

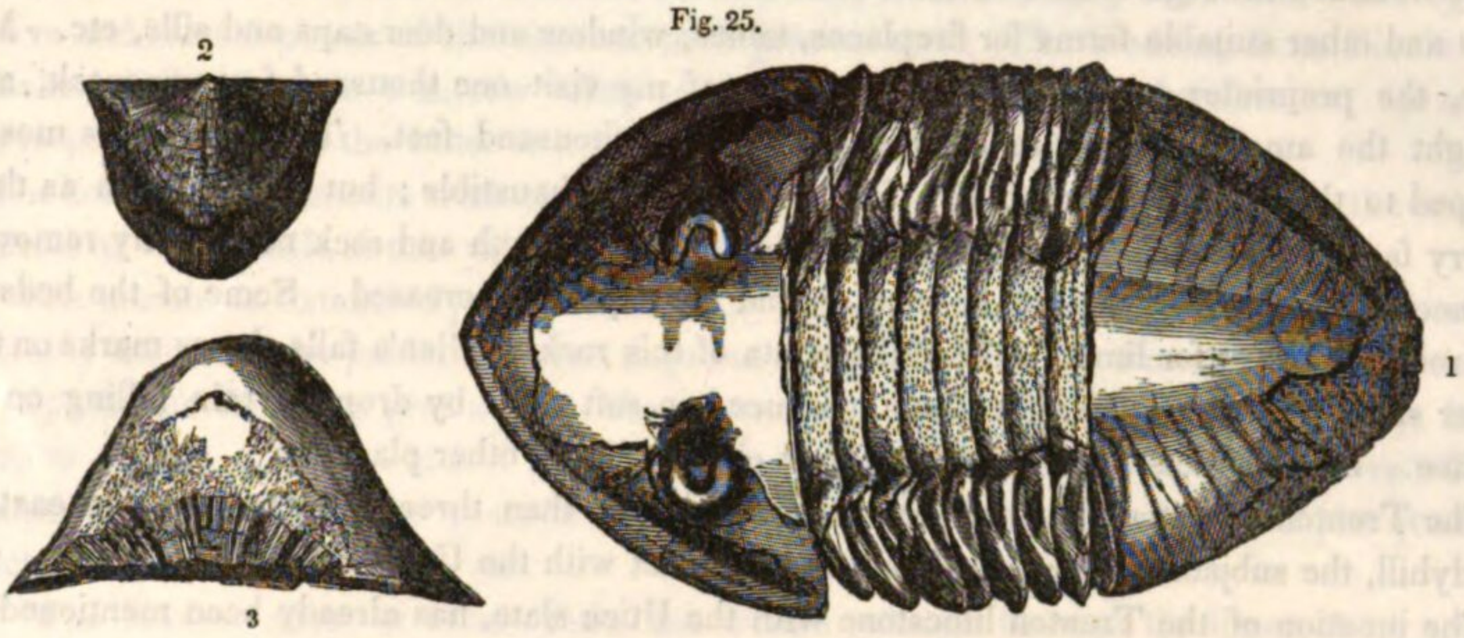
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* Eaton's Geological and Agricultural Survey of the vicinity of the Erie Canal, p. 69.

3. Trenton Limestone Group.

Synonims. *Trenton limestone* of the Geological Reports of New-York; *Metalliferous limerock* of Eaton. No. 2 of the Pennsylvania Survey. *Cliff limestone* of Ohio and Indiana Geological Reports.

Fig. 25.



1. Isotelus gigas. 2. Strophomena deltoidea. 3. Favosites lycopodites.

The rocks of this group are limestones and slates alternating with each other; and on the Mohawk and Hudson rivers some of the strata abound in fossils which are peculiar in character, and distinguish this group from others higher in the geological series.

The Trenton limestone group thins out from west to east, or is mostly replaced by the associated slates, so that it scarcely shows itself in the form of distinct limestone strata containing fossils, in the Mohawk valley east of Schenectady, or in the Hudson valley east of Baker's falls. To the east of the points indicated, the associated and underlying strata are exposed in very numerous places; but the Trenton limestone, when seen, exhibits itself in alternations of thin layers of black limestone, interstratified with black slate, and destitute of the fossils that abound in this rock where it has a greater development.

The Trenton limestone is generally a dark colored compact or subcrystalline limestone, sometimes slaty; in others in strata two to four feet thick, separated by thin layers of black shale. Some of the strata are replete with fossil remains, others are nearly destitute of them. Some of the thick strata are easily sawed and polished, and make a beautiful black marble; others contain hornstone and chert in small nodules and irregular masses, that render it useless for such purposes.

This rock occupies a small portion of Schenectady county near Amsterdam, on both banks of the Mohawk; thence it ranges northward into Saratoga county; thence eastward around the points of the mountains and along the eastern slope, and enters Warren county at Glensfalls and Washington county near Sandyhill. The Trenton limestone is extensively quarried

in Schenectady county, near the Erie canal, a few miles from Amsterdam, for building, flagging and curb stones, for the New-York, Albany, Troy, and other river markets. It is also quarried for stones for locks and aqueducts. It is a durable and valuable stone for such purposes.

At Glen's falls, on the Saratoga side of the Hudson, it is quarried for a black marble. It is easily obtained in large blocks within a few rods of the marble mills, where it is sawed into slabs and other suitable forms for fireplaces, tables, window and door caps and sills, etc. Mr. Rice, the proprietor, was sawing at the time of my visit one thousand feet per week, and thought the amount sawed in 1840 would be fifty thousand feet. This marble is mostly shipped to the New-York market. The supply is inexhaustible; but in proportion as they quarry farther from the banks of the river, the amount of earth and rock necessarily removed to uncover the marble beds will be greater, and the expense increased. Some of the beds of this rock are burnt for lime. One of the strata of this rock at Glen's falls shows marks on the upper surface of the layers, like those produced in soft mud by drops of rain falling on its surface. Similar facts have come under my observation in other places.

The Trenton limestone has not been recognized more than three or four miles northeast of Sandyhill, the subjacent limestones coming in contact with the Utica slate.

The junction of the Trenton limestone with the Utica slate, has already been mentioned as capable of being seen at low water of the Hudson, on the Saratoga shore above Baker's falls. Gentle swells or undulations of the rocks are seen between Baker's falls and Glen's falls. The strata are well exposed between those points, and nearly horizontal.

The following section, taken by Cadet Truman Seymour, is supposed to afford a good idea of the nature and relative quantities of each of the rocks of this group in that vicinity:

Section near Glen's falls, Saratoga county.

No.	Description of the strata.	Feet.	Inches.
1.	Thin layers of limestone alternating with compact slate	20	0
2.	Two layers of compact but rather coarse limestone	4	0
3.	Fine black shale	0	5
4.	Thin layers of limestone alternating with compact slate	20	0
5.	Compact limestone, one layer	5	6
6.	Ditto ditto in four or five layers	7	0
7.	Ditto ditto in very thin layers	8	6
8.	Compact slate	0	6
9.	Compact limestone, containing fossils	1	6
10.	Ditto ditto containing fucoids, indistinct	2	0
11.	Ditto ditto in thin layers, thickness unknown.		
		69	5

The strata numbered 2 and 5 are worked for marble and building stones.

In No. 3, a fine encrinite was found, perfect; and at the marble quarries, long spines in

graceful curves were seen in the thin layer of slate between the strata. The heads were generally so much enveloped in the solid limestone, that they could not be procured, without much labor, so as to expose their characters fully.

The Hudson at Glen's falls pours over successive terraces of the different strata, and rushes through the wide and deep chasms between the immense blocks of the limestone. These chasms were once the *joints* of the rock as it is supposed, but they have been worn by the erosive and solvent power of the water to their present size. The Hudson, from Glen's falls to Baker's falls, flows in a narrow valley or chasm in which, most of the distance, the rocks rise in precipices from the water to a height of thirty to one hundred feet.

The following statements were made to Prof. Emmons in 1838, in reference to the marble quarries at Glen's falls in that year (Vide Third Annual Geological Report, 1839).

"The marble is extensively manufactured by two enterprising companies; it is therefore favorably known to the public, and has acquired a high reputation. For this reason it would be superfluous for me to give a particular account of its qualities. I take the liberty, however, to subjoin a letter which I have recently received from the agent of the Glen's-Falls Company, in relation to the position of the marble in the quarry, and also of the quantity which has been manufactured, etc.

"'The Hudson river, at Glen's falls, has worn a passage through the limerock to a vast depth, rising in some places seventy feet from its surface. The strata measure from one inch to ten feet. A short distance from the river, on the Saratoga side, lying on limestone, is found black slate. Succeeding this are found strata of marble; slabs have been sawed and used for fireplaces. It is sound, and of good color. Succeeding this on both sides of the river, are found fifty strata of limestone, composed in part of organic remains. Next in succession are found strata of grey marble, two and a half feet thick; it receives a fine polish, but the color is not admired. A stratum of darker color follows this, which is six inches thick, though valuable only for step-stones. Then follows the black marble, which for brilliancy of polish and beauty of color, perhaps, has no rival. The whole stratum is ten and a half feet thick. Veins of organic remains run at irregular distances from each other through the strata; these veins are from two to four inches thick, running ten and sometimes twenty feet, and breaking off abruptly. Where these veins do occur, though they are not numerous, they rather mar the beauty of the marble. Who first discovered this marble, is not known, and it is of little consequence to inquire. Numerous attempts were made to work it, but without profit, until the present company received it.

"'The following exhibits the amount of stone which the Glen's-Falls Company have prepared and sent to market during the last four years. The company run sixteen gang of saws, which are equal to about one hundred and sixty single saws.

In 1835,.....	2,157	feet,	or 32,000	pounds.
1836,.....	19,800	"	278,500	"
1837,.....	23,400	"	333,900	"
1838,.....	25,000	"	352,500	pounds.'

"It is remarked farther by Mr. Roberts, the agent of this company, that the Glen's falls marble has gained a good reputation with most of the workers of marble in New-York, Boston and Philadelphia, as it regards its color, the polish which it receives, and the ease with which it works; and that it is considered equal to any of the kind in this country. He states that they have got out shelves for mantels seven feet and six inches long, thirteen inches wide and one and a quarter thick, which sells for sixty-five cents per foot. The price for this kind of stuff has fallen, and at present it is worth from fifty to fifty-five cents per foot; that which is shorter, from thirty to forty."

The following section was made by Cadet T. Seymour. I did not see the quarry at which the section was made, but presume it is, as he supposes, in the Trenton limestone.

Section at Marlit & Denham's quarries, near Hoffman's ferry on the Mohawk, a few miles east of Amsterdam.

No.	Description of the strata.	Feet.	Inches.
11.	Dark colored limestone, seven layers	6	0
10.	Black compact shale	2	3
9.		2	0
8.	Compact limestone (worked as a quarry stone)	1	4
7.	Slate	1	3
6.	Compact limestone (worked)	2	0
--		--	--
4.	Slaty limestone, compact	1	6
3.	Light colored limestone	1	6
2.	Dark colored compact limestone (worked as a quarry stone)	3	0
1.		--	--
		20	10

During the month of June, 1840, one hundred and one cubic yards of stone were taken from this quarry for the Erie canal.

Limestone of the Trenton group, and containing fossils, occurs in Greenbush, "five miles southeast of Troy," and about two miles from Albany; and "Schaghticoke, twelve miles north of Troy."*

In Orange county, near Mount Lookout, near Thompson's limekiln, some fossils are found in limestone, which, it is supposed, belongs to the Trenton limestone.†

The fossils of the Neeleytown limestone in Orange county have not been examined, but are supposed to belong to the Trenton limestone. This limestone is described by Dr. Horton as follows:

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* Vide Eaton's Geological and Agricultural Survey of the Erie Canal, p. 81.

† If it does not belong to the Trenton rock, it does to the Black river limestone, which forms Mount Lookout, and exists in other localities in Orange county.

"In Hamptonburgh, limestone exists as a bed in the argillite. This bed is about two and a half miles long, and fifty or sixty rods in breadth. The contact of the two rocks is no where visible, although they are within a few rods, and in some places but a few feet distant. This bed has the same direction and inclination as the argillite. It is all fetid, and contains cubic crystals of sulphuret of iron, which are of a bright yellow color. Most of the layers are the usual color of sparry lime rock; some, however, are very dark colored, so much so that it was supposed to contain coal. An excavation was accordingly made for this mineral; it need scarcely be observed, that no coal was found. The surfaces of some layers are full of the fossil shells of the very early periods of animal life. The stone of this bed has been long used for lime, but the quality is not very good. The argillite closes round both ends of this bed. It is called the *Neeleytown limestone*, in the neighborhood where it lies."*

The rocks of the Trenton limestone group occur on the bank of the Hudson, about one and a quarter to one and a half miles above the village of Barnegate. The rocks are slate and slaty altered limestones, that would not be recognized as limestones without close examination. Some few fossils were found in these altered argillaceous slaty limestones, that have been recognized as belonging to the Trenton limestone. The strata dip at a high angle to the east, like all the rocks in the vicinity.

Limestone and slate interstratified in thin layers were observed in many places in the masses of upturned strata of the Hudson valley, east of the anticlinal axis. They are supposed to belong to the Trenton limestone group, because,

1. They are composed of similar alternating strata of black and dark grey limestone and black shale.

2. They are often associated with such other limestones and calciferous sandstones, as we *know* are associated with and underlie the Trenton limestone group in some parts of the district, where the rocks are undisturbed.

A locality of this slaty limestone was observed on the macadamized road from Troy to Bennington, at the distance of about a mile from the Hudson river.

Another was observed at a quarry by the road side, on the east side of Kinderhook lake. The strike is N. 20° W., and the dip from 25° to 80° eastwardly.

Another in the banks of the Kinderhook creek at Malden, Columbia county. The layers at this place are thicker than on the east side of Kinderhook lake, being from six to ten inches, and they are interstratified with slate. It crosses the stream below the dam, and above the bridge, with a thickness of about thirty feet. Another mass crosses the stream under the bridge. The limestone is dark colored, compact, and intersected by veins of calcareous spar.

Another locality is by the road side, not far from Malden, where the limestone is interstratified with slate and grits.

Another locality is at Rider's mills, one mile above Malden. The rock has been blasted out here in many places above and below the dam, in the banks and bed of the stream, and

* Geological Report of New-York, 1839, p. 148.

in a quarry north of the bridge. The limestone at this, and at some other localities of this rock, is glazed with a thin black brilliant coating, that seems to be anthracite.

Another locality is near Canaan centre, where the excavations of the railroad have cut through these rocks.

At all these localities, the rocks are inclined at a high angle, and interstratified between other rocks belonging to the Champlain division.

Fossil Remains of the Trenton limestone.

Some species have been observed in the First district, that are believed to be undescribed, and may be expected to be figured and described in the Palæontological Report.

The following list contains some of the fossils of this group :

Isotelus gigas.
Calymene senaria.
Cryptolithus tessellatus.
Favosites lycopodites.
— several species.
Crinoidea, several species.
Orthocera striatum.
— duplex (C.).
Trocholites ammonius (C.).
— several species.
Bellerophon apertus.
Strophomena alternata.
— semiovalis.
— deltoidea.
Delthyris microptera.
Atrypa glabella.
Orthis testudinaria.

The above names are from Prof. Vanuxem's Report, and most of them were given by him.

4. Black-river Limestone.

Synonims. *Mohawk limestone, Birdseye limestone, Base of the Trenton limestone, Bald mountain limestone, Blue limestone, Chazy limestone, Black marble of Isle la Motte, Seven-foot tier*, and perhaps the *Neeleytown limestone*, of the Geological Reports of New-York; *Metalliferous limerock, Transition chequered* and *Sparry limerocks* of Eaton. No 2, of the Pennsylvania Survey.

Mohawk limestone.

This rock is more extensively developed in the First district, than the Trenton limestone. It is grey and compact, or subcrystalline in some places ; in others, a blue compact limestone. It ranges through Saratoga and Washington counties, along the base of the mountains of primitive rocks, resting on the projecting points, and dipping to the south ; but in the valleys, up which the strata are more or less extensively developed, they dip to the east-southeast with the primary, and on the east side of some of the valleys seem to plunge under these crystalline rocks.

The Mohawk limestone is found not only in continuous strata, but in numerous limited patches. It occurs on the shore of Lake Horicon, or George, opposite Sunday point,* in Washington county. There are several patches of it on both shores of Lake Champlain. It reposes in some places on the primary rocks. This may be seen at the north end of Washington county on Lake Champlain, near the limekiln on Mr. Goulard's farm. This patch of limestone extends south-southwest up a valley between the hills. Its dip is very slight. Another patch forms the shore two or three miles farther up the lake to the south, a little south of Negro point; crosses a small bay, and ranges up the valley of a small stream to the south-southwest. Between Negro point and the bay, the dip is to the north. Another range forms the shore on the Vermont side, nearly opposite this bay. Another range on the Vermont shore two miles south of the last, and this skirts the shore, or is but little distance from it, to the Narrows, three or four miles, where it forms perpendicular bluffs of limestone on both shores.

Many localities may be selected on the shore, where this dark grey compact limestone may be quarried in blocks of large size, and very near the water. The rock is one of the most durable and valuable kinds for buildings, locks, bridges and aqueducts. It may be easily quarried and dressed, and is very convenient to water transportation.

Another mass of this rock caps the top of the mountain east of Whitehall, dipping rapidly to the eastward, and broken by longitudinal faults into several broken ridges, and extends southward between Wood creek and Pawlet river, through the central part of Whitehall, the east part of Fort-Ann, the western part of Hartford; thence on by North-Argyle, Argyle corners, South-Argyle, Reed's mineral spring, to Bald mountain, where it *seems* to terminate, being covered over by the clays and sands of the quaternary formation of the Hudson and Batten kill. A similar limestone, and in the same direction, crosses the Batten kill at Galesville, at the falls, and thence ranges south about three miles, where it again disappears below the sand plains.

This rock is extensively used for making lime, and many kilns are in almost constant operation in Hartford, and Bald mountain, Greenwich, and in Easton near Galesville. The lime is in high repute, and from fifty thousand to sixty thousand bushels at least are supposed to be burnt annually. The lime is burnt with wood, so that the same kiln cannot be kept in constant operation.

Hydraulic cement for the Champlain canal, is made at and near Galesville. Several kilns have been in operation. The rock is quarried a mile or two miles south of Galesville.

There are several localities along this range where the strata are deranged in position, and the line of bearing changed from north-northeast and south-southwest to nearly east and west, by transverse upheaves, as at the south end of Bald mountain, and two or three miles southwest of Union village. The dip is almost uniformly to the east-southeast at a pretty high angle, except in localities where transverse lines of elevation or fracture exist.

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* This information was derived from Prof. Emmons. I did not see it.

This range of limestone is frequently accompanied by the "Calciferous sandrock," and sometimes by the Potsdam sandstone of Prof. Emmons. These rocks, however, were not observed at Bald mountain, or on the continuation south of Galesville.

A similar range of limestone was seen on the east bank of Pawlet river, near the northwest corner of Granville. Another in Salem, three miles south of the court-house. Another on the west side of that branch of the Owl kill that flows from the lakes in Jackson; this ranges north and south by Cambridge, two or three miles in length. Another about one and a half or two miles east of Wait's corners in Whitecreek, and here the calciferous sandrock is also present. These two rocks are associated near Cambridge centre, and four miles northwest of Cambridge, in Jackson, in several localities; also at Battenville, and thence range north by North-Greenwich and Summit lake to two miles northeast of Argyle corners. They occur also at Centre falls. These are isolated upturned masses, the connections of which have not been traced out.

Another range extends from near the northwest corner of Hoosick in Rensselaer county, up the valley of the Hoosick by Hoosick falls and Hoosick corners; thence up the valley of the Little Hoosick, through Petersburgh and Berlin to the Lebanon valley.

Local patches of this rock occur in various other places where the rocks have been very much broken up, as on Little White creek, near its mouth; on the Wallamsack, near its junction with the Hoosick river,* one mile, and two miles southeast of Hoosick corners.

The rocks in the region of country in which these various patches and detached ranges of imestone have been seen, have been broken up and upturned, so as to present an appearance similar to that produced by ice fields crushing against each other, and then freezing, so that the fragments stand edgewise at a greater or less angle of inclination. The dip and strike of these masses are variable, but in the aggregate conform to the adjoining rocks of the country, viz. to the east-southeast, north-northeast and south-southwest.

Another mass of the Mohawk limestone follows the range of the Trenton limestone, as far as I have described it in Schenectady and Saratoga counties; and in Washington county, it ranges along the base of the mountains in the valley of the west branch of Wood creek to Fort-Ann, where it joins the mass that ranges from Lake Champlain to Bald mountain (Vide the Map of the State).

Mount Lookout, in Orange county, a few miles from Goshen, near the county poor-house, is composed entirely of limestone of a dark color, generally of a fine grain and compact, and is supposed belong to the Mohawk or Black-river limestone.

"Its southern, western and northwestern boundary is a circular wall of limestone, about perpendicular, and at a distance having quite the appearance of trap rock. It lies in a position nearly horizontal, having but a very slight inclination to the west. In this neighborhood the limerock abounds in hornstone, generally black. When the western branch of this limestone reaches Great island in the Drowned lands, its dip is to the northwest, and so continues

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* The dip is here to the southwest, and the strike to the northwest.

to New-Jersey; the eastern preserves throughout its usual positions. A small portion of this limestone is found in Minisink, on the west side of the Drowned lands. This occurs at a point where the Walkill makes a considerable curve to the east.

"On Big island, in the Drowned lands, some of the layers of this rock are oolitic, in several places near the village of Warwick; also half a mile north of New-Milford."*

On Pochunk neck, this limestone, also nearly horizontal, is associated with the subjacent calciferous rocks. It occurs also in several places associated with the rocks of the Calciferous group, which will next be described.

There are numerous beds of limestone upturned and interstratified in the Hudson valley, the real geological ages of which are not known with *certainty*, but are *supposed* to belong to this group. Some of them *may* belong to the Water-lime group of the Helderberg division, but if they do, they seem to have lost all traces of the fossils usually associated with those rocks. The rocks of the Hudson valley are so much confused by derangements subsequent to their formation, that close, detailed and multiplied observations only can unravel the extremely complicated geology of that region.†

The following localities show beds of limestone that are supposed to belong to the Mohawk limestone, but they have not been examined with such care as to render it certain.

1. The west side of Canaan mountain, Columbia county, and at Whiting's mills in Canaan.
2. The dark colored limestone, in Kinderhook, about three miles east of the village, and west of Kline creek. It may be seen near Mr. Crocker's, in five successive ridges; some is sparry, and some is brecciated.
3. The same kind of limestone, in the limestone ridges in Ghent. Some of this limestone is sparry, some is dark colored and compact, and some is brecciated. It is nearly vertical, and is in successive echellon ridges (Vide Pl. 23, fig. 6).
4. The limestone along the eastern base of Merino mountain, near Hudson. This limestone is also seen on the road from Johnstown to Oakhill ferry, south of Blue hill. The rock is the blue limestone, sometimes grey or sparry, about thirty feet thick where observed, interstratified with slate, the junction with which was seen. The strike was N. 10° W., and dip 60° to 80° eastwardly.

   The same rock, it is supposed, was seen outcropping by the road-side on the farm of John E. H. Plass in Livingston, about five miles from Hudson. Its strike is N. 20° E., and its dip 70° to 80° eastwardly. Its junction with slate is visible.

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* Dr. Horton's Geological Report, 1839, p. 150: Third Annual Report of New-York. The oolitic rock probably belongs to the Calciferous group, like that of Warwick in Orange county, and Greenfield and Galway in Saratoga county.

† Had I the opportunity, it would give me much pleasure to spend some years in minute detailed investigations in this interesting region. The tracing out the continuity and extension of the fractures and lines of disturbance and fault transverse to the main axis; their connection with the metalliferous and other veins; the determination, more exact than has yet been done, of the periods at which the various derangements of the strata, elevation of mountains, injection of trap, quartz, granite, and various ores, were effected; the period when metamorphic agency changed many of the rocks, tracing definitely what rocks have been changed in their characters, and to what extent, by that agency; the determination of the equivalents of several anomalous rocks interstratified with the rocks of the Champlain division, are among the *desiderata* of questions connected with the physical geology of that region of country.

Along the eastern base of Merino mountain, the limestone forms a thick mass, underlaid apparently by the brecciated limestone. About one and a half miles south from the tavern at the south end of the salt marsh, the strike was N. 20° E., and dip 45° to 50° to the east-southeast.

5. The limestone in the west part of Hillsdale.
6. The limestone beds in Milan, crossed by the Pineplains and Rhinebeck turnpike, one and three-quarter miles west of Lafayette corners. The rock here forms a mass one or two hundred yards in breadth on the surface. It is compact, fine-grained, subcrystalline, and much is more or less "sparry" in consequence of its being traversed by veins. It probably dips under slate on the east (though the contact was not seen), and is succeeded by slate of a similar character on the west.

   A similar limestone is found in the east part of Redhook township, and in Clinton, ranging through the west part of Milan.
7. The limestone near Lithgow post-office, on the road from Poughkeepsie to Amenia.
8. Another similar limestone, but blacker, on the same road, about one mile from Washington hollow.
9. The limestones near Fishkill, Matteawan, Sprout creek, Poughquaick, &c. These limestones in Fishkill, Beekman, Pleasant-valley and Washington, are more or less altered by metamorphic action.
10. The limestone of Smith's clove in Orange county. It is abundant and well exposed to view near Galway's tavern, and may be seen in many places thence northwards towards Cornwall landing, with nearly vertical strata. Red slate is sometimes associated with this rock, as also with the 9th, 8th and 4th ranges of limestone.

Brecciated and Conglomerate limestone.

This limestone seems to have been formed by the breaking up of the Mohawk and Trenton limestones, and of the Calciferous group; and after the fragments had undergone more or less attrition, to have been cemented together. Very numerous localities of limestone of this character have been observed, most of which are in Columbia county. It often presents an aspect like the Potomac marble, but contains, in most of the localities observed, fragments of hornstone, basanite and siliceous matter in greater or less abundance, that would render it difficult to saw or polish.

Localities.—1. The brecciated and conglomerate limestone may be seen to great advantage at the stone quarries in the north part of Stuyvesant, on the bank of the Hudson (Vide Section, Pl. 23, fig. 8). The strike of the rocks at these quarries is about N. 10° W., and the dip about 30° to 40° to the eastward. The stone that is quarried is a greenish slaty rock of a fine-grain, with thick layers divided by joints, so as to present perfectly plane faces. The stratum quarried is thirty or forty feet thick,* and is represented by (*b*) in the section. This

* This rock is used for basements and foundations of houses, etc. in Albany. It has a fine grit, and would perhaps answer as a rubstone instead of the Scotch hone.

slate is underlaid by a series of alternating layers of slate and limestone. The limestone is compact, blue and grey. This stratum is represented on the section by (*a*).

Next above the slate that is quarried, is a stratum of the conglomerate and breccia limestone. It is composed of nodular and irregular masses, cemented by slaty matter like that in the stratum below. The limestone is dark blue and compact, and the slaty matter is greyish. Fine lines and veins of white carbonate of lime traverse the mass. This rock seems adapted to make a good marble, where very heavy, massive blocks are required. In consequence of the subjacent slate having been quarried out, the limestone has fallen down in huge blocks from a ton to twenty and thirty tons weight each; and the masses are of the thickness of the strata, or three to four feet thick, and bounded on their sides by the natural joints of the rock. The quarries are extensive along the shore, and the limestone has tumbled down in immense quantities.

Various modifications of this limestone form a bed twenty to forty feet thick, and over this is a slate rock (*d*); and still above a crystalline calciferous grit rock, probably belonging to the Calciferous group.* The limestones were traced south a full mile, receding from the river after the road strikes the upper marsh.

2. Strata nearly similar to those described, and some others, were finely exposed at Stockport landing by blasting for the wharf and warehouses. These localities, and Great Neuten hook, are recommended to students of geology as suitable places to examine the conglomerate limestone and some of the associated rocks.

3. On the southwest and northwest shores of Great Neuten hook, some of the rocks of the lower part of the Champlain division are well exposed to view. The strike of the rocks is generally about N. 10° to 20° W., and the dip about twenty degrees to the eastward; but on the southwest part of the hook, the rocks on the shore exhibit an inverted arch, on a scale sufficiently large to be distinguished on board the steamboats as they pass, but it may be much more satisfactorily seen by being on the shore. It is represented on Plate 24, fig. 2. The slate underlying the inverted arch, on the right hand side of the figure, is bent, twisted, knotted and fissured in every direction.

The following section is along the shore farther north on the hook, extending from near the house in the cove toward the west and southwest. The observer is supposed to face the south (Vide Plate 24, fig. 3).

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* The conglomerate at this locality belongs to the Calciferous group, or else the strata are inverted. This latter is not improbable, and the lower strata (*a*) correspond in some respects to the Trenton limestone, and others succeed in nearly their natural order.

Section of Rocks on Great Neuten Hook.

	FEET.	INCHES.
1. Limestone, compact, blue, brecciated, and interstratified with slate in thin laminæ	4	0
2. Brecciated limestone, siliceous and impure	2	0
3. Slate (fissile)	1	0
4. Breccia like No. 2	0	6
5. Slaty grit and gritty slate, interstratified, interlaminated and striped with fine slate	15	0
6. Limestone, breccia, like 2 and 4	2	0
7. Limestone nodules imbedded in slate	3	0
8. Limestone interlaminated with slate	2	0
9. Limestone, blue and compact, interstratified with coarse slate	9	0
10. Brecciated limestone	2	0
11. Black fissile slate	1	6
12. Brecciated limestone	2	0
13. Grit in layers half inch to one and a half feet thick, interstratified with fine slates, grey, black and yellow	20	0
14. Blue limestone like that east of Kinderhook or Fish lake, interstratified with finely laminated slate, both slightly undulating, and varying in thickness from half an inch to six inches	30	0
15. Grit, slaty, half an inch to one and a half feet thick, interstratified with fine striped slate, grey, black, yellow and brown	15	0
16. Alternating strata of sandy and compact grits, with seams of crystallized quartz; the grit strata are one to two feet thick, and alternate with gritty slate and slate	25	0
17. Grit (fine grained), but brecciated in some places	4	0
18. Slaty grits and gritty slates one eighth inch to fourteen inches thick, interlaminated with fine slate	25	0
19. Yellowish sandy glistening grit, in layers one to one and a half feet thick (calciferous rock)	5	0
20. Slaty grit in layers from two to six inches thick	5	0
21. Yellowish sandy grit	2	0
22. Slate, unknown thickness, sixteen feet exposed above high water mark	16	0
	191	0

4. At the north end of Great Neuten hook, the rocks dip both eastward and westward, so as to be about perpendicular to each other (Vide Plate 38, figs. 3–8). The strata consist of grits, slates and limestones. Great Neuten hook was once an island, but alluvial depositions have united it to the main land. The strata at Stockport landing and at Great Neuten hook are nearly the same, and the line of bearing is coincident in direction, and if prolonged from one, would reach the other. The strata generally, in that vicinity, range N. 20° W., about parallel to the trend of the shore between the points indicated.

5. The conglomerate limestone was seen in a quarry and a ridge on the road to Stuyvesant landing, about one mile from the road that leads from Kinderhook to Columbiaville. At the quarry, the strata are much contorted, as represented on Plate 9, fig. 17. The upper layers are brecciated limestone, and crushed and broken slate; and the lighter colored strata below, on that figure, represent the sparry limestone, and the dark colored strata are slate.

6, 7, 8. The conglomerate limestone was also observed on the road about midway between Kinderhook and Stuyvesant falls; also on the road from Kinderhook to Claverack, about one and a half miles from the former place, and at other localities; also about midway between Kinderhook and Groat's corners. It is associated with sparry limestone and calciferous rocks of the Champlain division, in successive parallel ridges.

9. The same rocks are also seen farther south in Ghent, in ridges which have already been described as being arranged in echellon.

10, 11. The same conglomerate limestone is also seen on the river road, two or three miles south-southwest from Hudson, as one of the lower layers of the limestone that ranges along the base of Merino mountain. It dips thirty to forty degrees to the eastward. Within half a mile of the locality last mentioned, it was seen again on a road leading eastward to the Highland turnpike.

12. The same rock was also seen farther south in Livingston, and forms a low range of hills about one mile west of the post-road.

13. About a mile south-southwest from Clermont, a ridge of the conglomerate limestone may be seen. It is interstratified with slate. Fragments of basanite are imbedded in it in some places.

14. The same rock may be seen on the post-road, between the 108th and 109th milestones from New-York. Some blocks from this rock were nearly black, intersected by white and yellow veins. Similar conglomerate was also in Clinton, on the land of Joseph Le Roy. In the east part of Rhinebeck, and four miles east of Rhinebeck village, Mr. Merrick states that the brecciated limestone occurs.

Numerous other localities of the limestone of this conglomerate and brecciated character were observed, but these are sufficient for illustration.

The aspect of this limestone is strikingly different from that called the *Sparry limestone* by Prof. Eaton, though both are probably of the same age, and constitute parts of the same mass in many instances. The principal difference seems to consist in the sparry limestone having been recemented *in place*, after having been shivered by subterranean forces; while the conglomerate and breccia have been more or less moved, and altered in form by attrition.

At Thompson's limekiln, about a mile northeast of Mount Lookout, in Orange county, is a locality where fragments of the Mohawk limestone have been rolled and cemented into a perfect conglomerate, the pebbles of which are from the size of bullets to that of large cannon shot; but instead of being *spherical*, they are *ellipsoidal*. The cement is also calcareous, and this rock makes the purest and best lime. The pebbles are of various colors, grey, brown and nearly black. Some fossils were found by Dr. Horton, associated with this limestone conglomerate; they belong to the Mohawk and Trenton limestones. These rounded masses are not *concretions*, but have evidently been formed by attrition.

5. Calciferous Group.

Synonims. *Barnegate limestone, Newburgh limestone, Warwick limestone, Oolitic limestone, Fucoidal layers, Slaty limestone,* of the Geological Reports of New-York; *Calciferous sandrock* and *Transition sandrock* of Eaton. No. 2 of the Pennsylvania Survey.

This group of rocks is intermediate in composition, as it is in age, between the Trenton and Mohawk limestones on the one hand, and the Potsdam sandstone on the other. The rocks are calcareo-siliceous; and sometimes one, sometimes the other predominates, and gives character to the rock. The water-lined laminæ of deposition are very conspicuous in some of the strata of calciferous sandstone.

The rocks of this group occupy a long narrow belt in the First geological district, extending from the New-Jersey line, south of Warwick and Pochunk neck, by Newburgh, Marlborough, Barnegate, Pleasant-valley, Pineplains, Ancram, Hillsdale, Canaan, Lebanon springs and Williamstown, into Vermont. There are numerous smaller patches where these rocks have been upheaved and exposed, that are not continuous for any considerable distance; and a similar remark may be made in regard to the long belt of limestone above described. It is not absolutely continuous, but has been fractured across, and heaved out of place along faults transverse to the lines along which the *principal* disturbances have taken place.

Barnegate Limestone.

The first continuous range of limestone of much magnitude that is seen in Columbia and Dutchess counties, in passing from west to east, is that which crosses the Hudson at Barnegate. It extends from Barnegate up Wappinger's creek, by Pleasant-valley and Pineplains into Columbia county, and on the south it passes from Milton by Newburgh, down the great valley through New-Jersey into Pennsylvania. Wappinger's creek forms the eastern boundary of this limestone range to near Attlebury. It crosses the valley of Pineplains under the great peat and marl marsh and Stessing pond. Mount Tom, at Copake flats, is a continuation of the same limestone. It varies in its characters from a sandy granular subcrystalline texture, to a perfect compact limestone, with a conchoidal fracture. This limestone is usually grey, granular, and subcrystalline, with grains of sand and minute quartz crystals disseminated. Small cavities lined with quartz crystals are common.

It is said to contain fossil remains, but they must be very rare, as I have not been able to detect a trace of one.* It is sometimes distinctly stratified, and even slaty near its junction

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* Mr. Briggs, in making his section from Poughkeepsie in Dutchess county, to Canaan in Connecticut, discovered faint traces of shells in the limestone at a quarry a little south of Pleasant-valley, on the bank of Wappinger's creek, but they were too imperfect for determination. "They were situated between the slaty layers, which dip to the south-south-east at an angle of thirty-five to forty degrees. Mr. William Thorn, of this place (Pleasant-valley), informed me that he had often seen shells in the limerock, although they are rare." (Mr. Briggs's Geological Notes of New-York Survey, Vol. ii, p. 252.)

with the slate rocks, but frequently its beds are so thick, and the masses of the ledges so broken, that scarcely any traces of stratification are visible.

This limestone is important, in consequence of its extensive application to the manufacture of lime. This business is not carried on extensively in Columbia county, but in Dutchess, at and near Barnegate, much lime is made.

The limekilns at Barnegate are kept burning constantly, from the opening of the river in the spring until the closing of it in winter, without allowing them to cool. The method pursued here is, after the kiln is once kindled, to charge about a half a ton of anthracite coal broken to the egg-size, then three hundred to three hundred and fifty bushels of limestone in lumps of twenty to thirty pounds each, and at the end of twelve hours another charge of coal and limestone; and so on, until the kiln is filled. They then draw out about three hundred and fifty bushels of lime from the bottom, and introduce another charge of coal and limestone; and every twelve hours this process is repeated. This operation is continued for months, as in a high furnace for smelting iron. A great economy is thus introduced,* the kiln being always kept heated, and the caloric which would escape in the common mode of manufacture is here expended in heating other portions of limestone, and preparing it for the high temperature necessary to expel the carbonic acid. About seven hundred bushels of lime are thus obtained daily from each kiln, with a consumption of a little less than a ton of coal.

Coal is delivered at the kiln at six dollars per ton; so that the expense of fuel is less than one cent per bushel, and that of attending kilns does not exceed one cent more, and the expense of raising and carting the stone is very trifling. Lime is sold on the wharf at six and a quarter cents per bushels; and vessels are always waiting for their cargoes, and take the lime as fast as it is burned.

This manufacture is the only business of any importance in Barnegate; six kilns are in constant operation, and there are others in the vicinity. About six thousand bushels are burnt per diem for nine months in the year, equal to seven hundred and twenty thousand bushels per annum. There are numerous other limekilns in Dutchess county, and it cannot be far from the truth to estimate their annual product at 1,500,000 bushels; this, at $6\frac{1}{4}$ cents per bushel, would yield an income of $93,750, and a nett profit of at least $30,000.

* The relative economy introduced by this method of burning, may be calculated from the fact, that in Connecticut, where lime is burnt with wood, and the kilns allowed to cool between each burning, thirty-five cords of wood are employed to burn seven hundred bushels at Brookfield, and forty cords to burn one thousand two hundred bushels at Reading.* Allowing wood to be worth two dollars and fifty cents per cord, the expense of fuel for burning is twelve and a half cents per bushel in the first, and eight and one third cents in the second case. The perpetual kilns of Pennsylvania yield seven hundred bushels of lime for every eight cords of wood, and one and a half tons of anthracite consumed.† In New-York, two thousand bushels of lime are burnt with twelve cords of wood.‡ We see here a striking example of the variable quantity of combustible to produce the same effect, and how great a saving may be made in this manufacture by judicious management. We have no knowledge of any limekilns that employ so small a quantity of combustible as those of eastern New-York.

* Shepard's Mineralogical Report of Connecticut, p. 82. † Idem, p. 87. ‡ Idem.

This lime is not as strong as that of Thomaston or Rhode-Island, and does not make as white walls. Most of the lime made at Barnegate is employed as a manure in New-Jersey, on their sandy soils, and it is found to be an excellent fertilizer.

The limestone near Barnegate varies much both in the direction and amount of its dip. The dip varies in amount from ten to ninety degrees, and in direction from east to south and south-southwest. The strata between the locality mentioned under the Trenton limestone as containing its fossils, a mile or one and a quarter mile above Barnegate, and the well characterized Barnegate limestone, are slaty, and interstratified with slaty laminæ in a position nearly vertical.

The country near Barnegate is a mass of little ridges of limestone, running back from the shore upon the main ridge between the Hudson and Caspar creek. The strata of these ridges generally dip southwardly about thirty degrees, and appear to be caused by a series of faults as represented on Plate 25, fig. 2 (Vide also Plate 28, fig. 4, for the topography.)

A fault or dislocation of the limestone may be seen about two hundred yards south-southeast of the tavern at Barnegate. It is perpendicular to those forming the ridges that run back from the river, and may easily be discerned in consequence of the different colored layers of the limestone. The heave or dislocation is about one foot, and is represented on Plate 25, fig. 1.

The limestone extends along the Hudson river on the east shore, from Barnegate to Hamburgh at the mouth of Wappinger's creek, which is the southern limit on that shore, but is concealed in some places by the quaternary and alluvial deposits, as at the mouth of the Caspar creek (Vide Pl. 28, fig. 4).

Dr. Horton, describing the limestones of this group in Orange county, under the titles of *Blue limestone*, *Sparry limestone*, and *Chequered limestone*, says,

"A stratum of this rock commences on the bank of the Hudson at Hampton, where Orange is bounded by Ulster county. It is about one mile in width from northwest to southeast. Its direction is very nearly south-southwest, passing about a mile northwest of the village of Newburgh, into the town of New-Windsor, and disappears beneath the surface finally in the vicinity of a small body of water called Little pond, in the latter town. With the exception of one locality, its dip is to the southeast at an angle of thirty to sixty degrees. The exception referred to is at Hampton, on the bank of the river; here this rock attains an elevation greater than at any other point in this stratum, and the oblique ends of the layers as they come out to the river bank appear as if they had been elevated into a position which gives them a dip of thirty to forty degrees to the west and northwest. The elevated point of this rock at Hampton, and a similar but less elevated one a little below, called the ———, form the northern termination of the long bay of Newburgh.

"Many of the layers of which this stratum is composed, are from two to four feet thick; they are solid, compact, and some of them break with a perfect conchoidal fracture. The layers differ considerably in color, part being a very light and part a very dark grey, and both are traversed in all directions by narrow seams and veins of white calcareous spar. Occasionally nests of quartz crystals and brown spar are noticed. I have not discovered a fossil

in this rock, nor could I learn that any have been seen by others. In a quarry of this rock belonging to Mr. Charles Collier, the surfaces of the layers are covered with a very white incrustation, which forms handsome specimens. It has the appearance and hardness of arragonite. Veins of white quartz and nodules of black hornstone are common in some of the layers. This stratum is employed extensively for burning into lime.

"Another stratum of sparry limerock, farther to the south and east, makes its appearance about a mile east of Salisbury mills, in Cornwall. It is here but a few rods in width, and not far distant from Skunnemunk mountain. It is visible, with a few interruptions, across Bloominggrove and Warwick, to the State of New-Jersey. It is seldom more than a mile in width. It resembles closely the stratum near Newburgh, but at no point rises so high above the surface. In the village of Warwick, it affords good specimens of crystallized quartz and crystallized brown spar. Fifty or sixty rods west of the Presbyterian church, in the same village, some of the layers are of a light red color, very close and compact in structure, and gives the argillaceous odor when moistened. The lustre is quite dull, and it breaks with a flat conchoidal fracture. There is evidently much clay in the composition. It has been supposed to be the water-lime, but there are more glimmering particles in it than in the hydraulic lime of standard localities. It has also been examined in reference to its fitness for a lithographic stone, but does not prove good. It is called red marl in that vicinity.

"The minerals noticed in this rock, are quartz crystals, crystals of brown spar, crystals of oxide of titanium, and magnetic iron ore, so strong as to have given it the name of native magnet.

"Limestone exists abundantly in the town of Monroe, particularly in the north and northwest part of it. It is abundant about two miles north of Greenwood furnace, near the point where the Ramapo river enters the Highlands. It is here spread out to a breadth of nearly two miles, and a part of it extends southwesterly to the neighborhood of Long pond. It is much used as a flux in the iron furnaces, and but very little for lime.

"A small bed of similar limestone is found in the town of Cornwall, half a mile southwest of Ketcham's mill. It is stratified, and dips to the southeast.

"Limestone is also found in great abundance in Goshen. It begins two and a half miles southwest of the village, and extends from the Walkill southeast to Thompson's pond, a breadth of six or seven miles; and in length to the south and west, it extends into New-Jersey across the town of Warwick, west of the stratum already mentioned.

"The western edge of this limestone underlays the drowned lands and most of the islands in them, and passes along the northwestern margin of the white limestone of Warwick. Another part of the same rock passes along the whole southeastern margin of the same limestone, and crosses the line of New-Jersey with it. In other words, when this limestone meets the primitive rock, it divides into two branches; one proceeding along the northwestern, and the other along the southeastern margin of the primitive, until they all enter New-Jersey. I have not seen them in contact, but they are everywhere in close proximity; no other rock intervening. At the line of New-Jersey, this rock, with the included primitive, occupies a breadth of nearly eight miles.

"The northern terminations of the ridges of this limestone interlock with the southern terminations of the argillite ridges. This singular interlocking of the two rocks can be finely seen three and a half miles from Goshen, and half a mile southeast from Mapes's tavern; also a little farther southeast, at the limekiln of Mr. H. W. Thompson. Most of the limestone of Orange county is precisely similar to that from which so much and such superior lime is made in Newburgh, and care and experience only are required in selecting and burning to obtain as good lime. This statement is necessary, since the belief has become common, that there is little if any good limestone in the county, except at Newburgh; and as a consequence, the Newburgh lime has comparatively excluded all other from use.

"It is a common belief in the county, that the limestone from beneath the surface requires less fuel to reduce it to lime than that taken from the surface.

"As a building material, some of our limestones are not surpassed by any found in this State. Those of Neeleytown in Hamptonburgh, and Mount Lookout in Goshen, are peculiarly fine. That of Mount Lookout is a handsome dove-color, and perfectly durable. It can readily be obtained of any length and thickness required."*

This limestone occupies a small area near Marlborough, in the southeast corner of Ulster county. It lies south of the creek, and covers an area, probably less than one hundred acres. The dip, where seen, was the same as that of the adjacent slate rocks, viz. E.S.E. from 20° to 70°.

Calciferous Sandstone.

The Calciferous sandstone is an intermediate link between the Potsdam sandstone and Mohawk limestone, and composed of the same ingredients as these rocks, but the siliceous material predominates.

This rock ranges through Washington county, underlying the Mohawk limestone in most places where the limestone occurs. This rock, like the limestone, laps around the points of the mountains and up the valleys, very much deranged in its stratification near the primary rocks. It may be seen in numerous localities between Fort-Ann and Patten's mills, in the valley of the west branch of Wood creek. From one mile east of Fort-Ann, it may be traced by Comstock's landing to Whitehall, where it may be seen in the mountain east of the village. It may also be seen in most of the ridges for three miles to the east of Whitehall, and in some places it has been quarried for building stone, and for the locks on the canal.

Several ranges of this rock, caused by the rocks having been upheaved into parallel ridges, are associated with the limestone described as occurring at the lead mine in White creek; also near Cambridge centre; three miles from Cambridge, on the road to Union village; four miles north-northwest of Cambridge; at Battenville; Centre falls, and thence north on to the southeast part of Summit lake; near Union village, and several localities in a line nearly north to the northwest part of Summit lake; southwest of Hebron, two and four miles; seve-

* Dr. HORTON. Third Geological Report of New-York.

ral places between South-Granville and Fairvale; and several in the west part of Hartford, and east part of Fort-Ann.

The same rock has also been observed in numerous places in Rensselaer and Columbia counties; but the limestone is there thin, and in some places absent, as at the quarries near Lansingburgh.

Quartz crystals were observed in some abundance in a rock intermediate between this and the limestone, in Galway, Saratoga county; and at Diamond hill, one mile south of Galway, the rock is geodiferous, and contains many quartz crystals. Some of the geodes are lined with crystals of calcareous spar.*

Oolitic Limestone.

An oolitic limestone has been observed in several localities in the Calciferous group, both in New-York and New-Jersey.† It is a common rock along the southern extremities of the Palmertown and Kayadarosseras mountains in Saratoga county, and has been described by Dr. J. H. Steel.‡ "The calcareous concretions, which characterize and identify this formation, are, for the most part, arranged in successive layers throughout the strata in which they appear; they are globular, of the size of mustard seed, possess a shining black color, and are evidently composed of concentric layers. They are united in the mass by a calcareous cement, more or less granular, combined with fine siliceous sand.

"More than one-half of the whole mass of some of the strata which constitute the series of this formation, consists of these globular concretions; in others they are more sparingly diffused, and some of the strata appear to be composed altogether of a calcareo-siliceous sand, without the intervention of a single globule. These are mostly of a darkish grey cast, but they are in some places rendered brown by the intervention of ferruginous particles.

"In and near the road which leads from Greenfield to Ballston-Spa, by the way of Rowland's mills, on the farm of Deacon Wood, is a bank composed of a series of horizontal strata, where the peculiar characteristic features of this formation are well defined, and may be readily examined.

"One of the strata at this place presents a very singular appearance, and one which, if it occurs elsewhere, has never been noticed, so far as I am able to learn, by any writer. The surface of this stratum is fairly exposed for a number of rods to the north and south of the bank beneath which it evidently passes. It is about two feet in thickness, and has imbedded throughout its substance great quantities of calcareous concretions of a most singular structure;

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* Anthracite in small pieces is frequently found in the calciferous rocks, and most frequently in the cavities of the strata in which the quartz crystals occur so abundantly. This is supposed to be the source of the small fragments of anthracite that are so often seen in the grits and slates of the Hudson-river group; since these latter rocks are partly formed of the ruins of the lower portion of the Champlain division.

† Vide Geological Report of New-Jersey, by Prof. H. D. Rodgers, p. —; Robinson's Catalogue of American Minerals, p. 165; American Journal of Science, Vol. xix, p. 398: at Edenville (Dr. Young).

‡ American Journal of Science (J. H. Steel), Vol. ix, pp. 16, 19.

they are mostly hemispherical, but many of them are globular, and vary in size from half an inch to two feet in diameter; they are obviously composed of a series of successive layers, nearly parallel and perfectly concentric. These layers have a compact texture, are of a dark blue or nearly black color, and are united by intervening layers of a lighter colored calcareous substance, either stalactitical or granular;* they are very thin, and I have counted more than a hundred in one series. By breaking the matrix in which they are imbedded, they drop out entire, and may be readily reduced to any smaller size by merely throwing them upon the rock; the concentric layers easily separate, leaving the form exactly the same.

"These interesting concretions appear to be confined solely to one stratum of the series, and this stratum evidently accompanies the oolite in its whole extent, and is undoubtedly a variety of the same series, the best characterized oolite lying beneath, while those of a less definite character are regularly piled above."†

The structure above described is illustrated on Pl. 40, fig. 2.‡

The same kind of rock was seen in Galway, both north and south of the road that leads east and west through Galway corners. Between Galway corners and Diamond hill is a small anticlinal axis ranging eastward and westward, the strata dipping to the north and south. The next northward locality seen in Galway, is about three miles north of the village called the Corners, and near the primary rocks.

"There is a bed of oolite about four miles north of Saratoga springs. It is of a dark color, and is made up of grains about as large as a pin's head. On analysis, I found its composition to be as follows in 100 grains:

Carbonate of lime	95.00
Silica and alumina, with some carbonaceous matter	5.00."§

Oolitic rocks have also been observed in the blue and grey limestone of the Calciferous group in various parts of Orange county,‖ viz. on Big island, in the great marsh called the Drowned lands; near Edenville, in Warwick; several places near the village of Warwick; half a mile north of New-Milford, and on Pochunk neck. Dr. Horton, in his description of the limestones of the Champlain division in Orange county, says,

"On Pochunk neck, about three miles from the New-Jersey line, some of the layers differ from any seen in the county. In some of the perpendicular cliffs, the edges of many layers are exposed, one above another. Some of these are of the usual character, others are oolitic, but the round granules are bluish white quartz; other layers still are slaty,

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* Some of the round masses described as concretions analogous to oolite, are *organic*, and will be described in the Palæontological Report. Similar concretions and ovoidal masses in a similar geological portion, and associated with equivalent rocks, have been observed in various parts of the valley of the Mississippi, particularly in Missouri and Wisconsin.

† American Journal of Science (STEEL), Vol. 9, pp. 16, 18.

‡ Copied from the American Journal of Science, Vol. 9, Plate 2.

§ Prof. BECK's Report, 1840, p. 96.

‖ The extension of the same limestone contains oolite in Franklin in New-Jersey, and near Easton in Pennsylvania (American Journal of Science, Vol. 18, p. 376; Vol. 19, p. 398).

approaching the calciferous slate. Some of it has a ribbon-like appearance, the laminæ of light and dark grey alternating in the layer. A locality, nearly similar, may be seen at Bellvale, on the land of Mr. Wilson. At this place some of the layers contain but little lime, and approximate closely in appearance the calciferous sandrock of Prof. Eaton."*

Slaty Limestone.

A slaty limestone is associated with the slate rocks, which, without close inspection, would be passed over as a slate. It is an argillaceous limestone, so marked in its characters, so constant in its appearance, and contains the impressions of what are supposed to have been a species of fucoid that has not been seen in any other rock in the series, that it is a great aid in tracing the strata. It enables us to demonstrate the breaking up of the strata.

This peculiar rock has been found in the successive ranges of hills, and in the same order of superposition with all the strata in each, and dipping in the same direction. In some places this material may be usefully employed for hones. I have used it for setting a fine edge. It has been used as a flagging stone and coping stone, and is well adapted to these uses. It is easily split out in smooth slabs. It has been observed in a great number of places in Washington county in its southern part, from the western to near the eastern side. It may be seen well characterized at Centre falls on the Batten kill in Greenwich; also near Battenville; on the road from Cambridge to Union village; on the road from Cambridge to Battenville; on the road from Reed's mineral spring to Argyle corners, at some quarries, and in other places; near Cambridge centre; one mile west of Hebron; four miles southwest of Hebron; at Hartford lower village; between North-Granville and Middle-Granville in several places, as at the falls, one mile above, one-fourth of a mile northeast, and at Middle-Granville.

The rock, when long exposed, is grey on the exterior, and the fucoidal marks imperfect. I examined many specimens before I was fully convinced that the markings were from organic bodies.† The fresh fractures of the rocks shows a slight mottled appearance, as if the carbonaceous matter of the fucoid had penetrated into the mass below and above the place where the impression remains.

This rock is almost uniformly found near the Calciferous sandstone, with a thickness of from forty to sixty feet of slate intervening.

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* Third Annual Geological Report of New-York, p. 150.

† The Rev. Mr. Newton of Cambridge, who is an ardent admirer of geology as a science, and who is an active and useful laborer in geological instruction and observation, first called my attention to the fucoidal impressions in this calcareous slate near Cambridge, and I have to express my thanks for his kind coöperation in aiding my investigations in the south part of Washington county.

6. Potsdam Sandstone.

This rock underlies the Calciferous sandrock; and this latter is intermediate in composition, as well as in age, to the Potsdam sandstone and Mohawk limestone. It seems to have been deposited during the period when the cause producing the Potsdam sandstone was diminishing in its effects, and that of the limestone had commenced, and was increasing.

The Potsdam sandstone is a hard siliceous sandstone, white, red, grey, yellowish, and frequently striped. It is well developed at Whitehall, where it has a thickness of one hundred and fifty to two hundred feet. It extends up the valley of Wood creek in a southerly direction by Comstock's landing, one mile east of Fort-Ann; and so on farther south, diminishing in thickness, and becoming interlaminated with finer grained strata of grits, slates and shales.

Some of the strata of this rock are covered with the most beautifully characterized ripple-marks, as perfect as if just formed on the sand of a sea-beach, while the rock is of the most indurated kind of sandstone. Fine examples of these may be seen in the flagging stones in the sidewalks of the village of Fort-Ann. Many places in the vicinity, and between that village and Comstock's landing might be referred to, where they may be seen in the rocks *in place*. Fucoidal impressions were also seen in some of the strata of this rock.

The Potsdam sandstone is used but little, and that little for flagging and building. It can be quarried in fine blocks twelve to sixteen inches thick, with plain surfaces on the bed and top, but it is a hard stone to dress. It is one of the most durable kinds of rock.

Boulders and pebbles of the Potsdam sandstone, and the granular quartz of the Bennington range, (and which I believe to be the same rock more changed as a metamorphic rock,) form a large share of the mass of the gravel and pebble beds of the plains along the Hudson, and more particularly in the high pebble-bottomed valleys of the highlands of the Hudson. Some of these pebbles are so compact and hard, as to pass for coarse red and striped jasper.

The Potsdam sandstone was seen in several places; and in some, its lower part in particular, is a metamorphic rock having more or less the aspect of gneiss, except that mica is absent. In another locality, half a mile west of Putnam ferry, where it overlies granitic rocks, it is in an intermediate state, having the general aspect of a primary rock, but still shows its rounded gravel and sand. The usual dip is to the eastward, at variable angles from five to twenty degrees; but in the Hudson valley, where it is exposed in numerous localities, upturned with other rocks, it dips at high angles to the eastward. The Potsdam sandstone, somewhat altered in texture by metamorphic agency, may be seen at the south end of Mount Stessing, underlying the limestone of the Calciferous group. Many localities of this rock might be mentioned, but the rock can be best studied between Whitehall and Fort-Ann, and in the valley of the west branch of Wood creek in Washington county, and in Galway and Greenfield in Saratoga county.

The following section in Galway, illustrates the Potsdam sandstone, and the base of the Calciferous group.

	FEET.	INCHES.
1. Argillaceous conglomerate	1	2
2. Limestone	0	9
3. Limestone, argillaceous	0	9
4. Gray siliceous hard sandstone	40	0
6. White ditto ditto	2	0
7. Grey ditto ditto	25	0
8. Quartz	10	0
9. Siliceous fissile slate	15	0
10. Whitish quartzose sandstone	8	0
11. Sandstone (slaty)	6	0
12. Sandstone (compact), unknown thickness.	..	..
13. Primary rocks, gneiss, etc., unknown thickness.	..	..
	108	8

The position of these rocks and their associates is indicated on Plate 28, fig. 1, where the Potsdam sandstone rests on the gneiss rocks, and the calciferous rocks upon the sandstone.

It has been mentioned that the general dip of the Potsdam sandstone was to the east; but along the extremities of the southern spurs of the primary mountains in the southwest parts of Washington and Saratoga counties, the strata have a more general dip to the south. On the eastern side of these projecting spurs, the strata dip to the eastward; and on the western sides, they sometimes dip to the westward, and sometimes seem to plunge beneath the primary rocks.

Roofing Slate.

This rock might, with propriety, it is believed, have been described under the head of Utica slate; but it is an altered rock, intermediate in character (as are also its associates), between the rocks described under the Champlain division, and those to be described under the "Taconic system."

The roof slate ranges from Vermont, through Washington, Rensselaer, Columbia, Dutchess, Ulster and Orange counties, into New-Jersey and Pennsylvania, and is quarried for roof slate in many places. This rock and its associates, which are similar to those already described under the Champlain division, are penetrated by quartz veins in great numbers, and by interlaminations of quartz, so that in many places the rocks seem permeated by this mineral as a sponge is filled with water, and this has given a modified character to the rocks. This character may be seen illustrated in the hills near Redrock village in Canaan and Austerlitz in

Columbia county, and farther south in Hillsdale, Copake, Ancram and Gallatin (Vide Plate 10, fig. 14; and Pl. 23, fig. 7).

In most of the localities that will answer for roofing slate, the laminæ of cleavage and of deposition are coincident. This is evident, 1st, by the distinct stratification of the rock; 2d, by its frequent striped aspect parallel to these divisions; and 3d, by the vegetable impressions (graptolites) being situated on and parallel to these cleavage planes, and not transverse to them.

Details. The roofing slate ranges through Rensselaer county, from two miles west of Lebanon springs to the northeast corner of Hoosick; thence north in Washington county through the towns of Whitecreek, Jackson, Salem, Hebron, Granville and Hampton; and thence an unknown distance into Vermont. There are many places where it may be wrought for roofing slates, when there shall be facilities for transportation, such as to enable the proprietors or adventurers to send them to market without too great an expense. At present the Welch slates can be afforded in our coast markets at a less price than the Hoosick slates, although the facilities for raising these slates are very great. The expense of transport over land to Troy, and a prepossession in favor of the Welch slate, has prevented the Hoosick quarries from being wrought as extensively as they might have been. The prepossession in favor of the Welch slate is believed to be unfounded. As beautiful slates are obtained from the Hoosick quarries as I have ever seen, and they are as durable. There are two qualities of the slate obtained from these quarries, viz. the blue, and the grey or fucoidal slate. The former retain their bright bluish surfaces for many years, and probably will as long as the slate shall last; they do not show the slightest indications of change after many years exposure.

There is another stratum of slate several feet thick, containing a multitude of the most beautiful impressions of plants, supposed to be fucoids. This stratum makes good slates for use, but they are not as beautiful, and they become greyish in a few years. These are sold at a much less price than the blue slates; and it is supposed, that in consequence of the change of color, the quarries do not sustain as high a reputation as they did in former years. The principal quarries are those of Moses Warren, one mile north of Hoosick corners; and those of Obadiah Crane, two miles northeast of the above.

The strata dip to the eastward about thirty degrees, but they are somewhat bent. The curves are so large, (having radii from one hundred to three hundred feet,) that the masses taken out do not show any distinct curvature. The strata are intersected by thin veins of quartz, which is frequently fibrous.

A range of roof-slate extends from New-Lebanon through Canaan, Austerlitz, Hillsdale, Copake, Ancram, and Pulver's corners in Northeast. It is believed to be the same as that in which the Hoosick quarries are located. Quarries of roof-slate have been opened in this range of rock in many places. The most important are those in New-Lebanon, about one and a half miles from the springs on the east face of the mountain. One belongs to Charles B. Gillet; the other, which is about a half or three-quarters of a mile north of the first,

belongs to the Rowley family. This last has been extensively worked, but for many years slate has been so cheap as to render the working of these quarries unprofitable. The slate is of good quality, (but softer than the Welch slate,) and there is an inexhaustible quantity of it.

At Hillsdale, a quarry of slate was wrought extensively some years ago, by Mr. Foster. The slate is of good quality where it is free from pyrites, but a large portion of it contains disseminated cubic crystals of this mineral. By exposure to the weather, the crystals decompose, and leave cubic cavities in the slate. The pyrites is an injury to the slate, not only by leaving cavities through which leakage might take place after it should be placed on roofs, but by its decomposition it changes the texture of the slate.*

Many localities were also observed in different parts of this range, at which quarries have never been opened, but which would undoubtedly afford roofing slate of a superior quality. Others no doubt might be discovered, should the price of the article justify a further exploration. Indeed the quantity of slate, suitable for roofing, contained in this range of mountains and hills, can be estimated only by saying that it is sufficient to supply a nation's wants for ages. From its observed range and extent, it is believed that careful examination would lead to the discovery of favorable locations for working it for roof slate, in Dutchess and Ulster counties near the Hudson, where the range of rock crosses the river, and in Vermont at no great distance from Lake Champlain.

Roof-slate is frequently carbonaceous, and passes into graphic slate. A locality of this slate is in the road near Mr. Asa Pelton's, and near the line between Austerlitz and Hillsdale. It had been described to us as a locality of black oxide of manganese. This variety of slate also occurs on the mountain one and a half miles south of Hillsdale; in Ancram, one-half mile to one mile west of the lead mine, and in many other places; but it is not so black in these two last localities as in other places. It breaks out in columnar fragments. Much of this columnar slate is similar to pencil slate, and might probably be applied to this use.

Many of the slate rocks of Columbia and Dutchess counties are so loaded with carbon, either disseminated or in thin films of anthracite, which fills the natural fissures, cleavages, and breaks of the rock, that many persons have expended time, labor and money in digging for coal.

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* About half a mile southeast of Bain's tavern, is an old slate quarry. A quarter of a mile north of Pulver's corners in Northeast, roof-slate from the same range, containing cubic cavities, is used as a fire-stone. This kind of rock, laid edgewise, is generally used for the lining of furnaces in that part of the country.

CHAPTER VII.

TACONIC* SYSTEM.

This system consists of slates, limestones, and granular quartz rocks. They form a belt of mountainous and hilly country, from Vermont to Peekskill on the Hudson river, along the eastern line of New-York, across the counties of Washington, Rensselaer, Columbia and Dutchess to the Highlands, and a narrow belt across the Highlands to the mouth of Peekskill creek. They reäppear on the right bank of the Hudson between Stony point and Caldwell's landing, and range south-southwest until they disappear beneath the Red-sandstone formation near the Minisheconge creek in Rockland county, southwest of Stony point. They occupy also a variable breadth of country in the southwest part of Vermont, and in the western part of Massachusetts.

The strike and dip of the rocks of this system are in the same directions as those of the Champlain division, and *apparently* overlie them. The dip is to the east, east-southeast and east-northeast, at angles varying from fifteen to ninety degrees. Although the rocks *all dip in the same general direction*, similar strata at no great distances are frequently *reversed in their relative order of superposition*. This is more frequently observed on the opposite sides of ridges of hills and mountains.

It will be observed by consulting the numerous sections between the Hudson and the lines of Massachusetts, Connecticut and Vermont,† that the talcose slates that belong to the Taconic system *are not confined to the belt that has been described as ranging along the east line of the State of New-York to the Highlands*, but that *local patches of it are found in many places*. The rocks of this system are more or less distinctly characterized where they approach to gneiss and granite rocks, and where quartz has been intruded most abundantly among them.

Where the exact order of superposition of these rocks and the primary can be examined,

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* This name is also frequently written *Taghkanic* and *Taconick*, but formerly *Toghconnuck* and *Toghconnuc*. The name *Taconic System* was given by Prof. Emmons, to designate the rocks forming the Williamstown mountain range. They are very peculiar in their aspect, but blend into the Champlain division on the one hand, and into the Primary rocks on the other.

† Vide Plate 12, fig. 8; Pl. 13, figs. 3, 4, 5, 6; Pl. 14, figs. 1, 2, 3, 4, 6; Pl. 16, figs. 1, 3; Pl. 17, figs. 1, 2, 3; Pl. 18, figs. 1, 2; Pl. 23, figs. 2, 4, 5; and Pl. 28, fig. 1.

it is found, 1st, that the granular quartz either rests upon, or pitches immediately under the gneiss or granitic rocks; 2d, that the limestones lie next in order from the gneiss or granite, either in super or sub-position; and 3d, that the slates next follow. The observer may find much difficulty in verifying this, as the rocks are almost universally much deranged from the position in which they were deposited; but from numerous observations made, the above is believed to be the order of superposition. The observer may be referred to the gorge near Bennington iron works in Vermont, for the superposition of the granular quartz and limestone, although the latter is generally so much deranged as to make it difficult to trace it out. Another locality where the connection may be traced, is on the southwest side of Mount Stessing, in Pineplains and Stanford, Dutchess county.* Another, where the order of succession on the surface is the same, though the exact *superposition* was not *seen,* may be examined east of Fort-Ann, Washington county, where the Potsdam sandstone reposes on the Primary rocks, and is succeeded successively towards Hartford by the limestone and talcy slate. The same may be traced east from Whitehall, where the slate becomes talcy and chloritic.

The sandstones of the Taconic system are grey, reddish, striped and white; all of which are very hard, tough, indurated quartzose rocks.

The limestones are grey and black, compact in some places; crystalline, grey, and sparry or checkered limestone in others; and not unfrequently they are granular, whitish, crystalline limestones. The same continuous rock has undergone the above changes at different localities, in proportion as it has been less or more subjected to the influences that have modified them.

The slate rock has undergone as great changes. It varies from argillaceous slate through graphic slate, plumbaginous slate, to chlorite slate and talcose slate. Modifications of the two latter are most common, sometimes mingled with blue, green, red and mottled slates. The slate rock is generally more or less permeated by veins and bunches of milky quartz, and the quartz often contains chlorite and brown spar disseminated in bunches. These minerals are most abundant where the rock is most intersected and permeated by the quartz, and in such localities the rock approaches most nearly to chlorite slate.

The Taconic rocks can be seen well exposed to view on the road from Cambridge in Washington county, up the Battenkill to Arlington in Vermont; also between Salem and Rupert, and between Hebron and Rupert; on the road between Hoosick four corners in Rensselaer county, and Williams College in Williamstown, Masachusetts; between New-Lebanon in Columbia county, and Pittsfield in Massachusetts; between Hillsdale and Egremont; between Pineplains in Dutchess county, and Northeast; between Attlebury and Leedsville; between Amenia and Dover; between Beekman and Dover, and Unionvale and Dover. In some of the latter localities the rocks are more changed than in the proper rocks of the Taconic system, and more properly belong to those that will be described as metamorphic rocks.

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* The sandstone and limestone at the southwest part of Mount Stessing, have already been referred to under the Champlain division. The sandstone is indurated by metamorphic agency, and may with propriety, perhaps, be classed with the Taconic rocks; inasmuch as these latter are considered the same as the Champlain division, slightly modified.

The slate rocks are also talcose in the northeast part of Milan and northwest part of Pine-plains in Dutchess county, and between Whitehall and West-Poultney in Washington county. The rocks of this system that traverse the Highlands may be examined south of Johnsville in Fishkill, Dutchess county; at and near Gallows hill, and at the mouth of the Peekskill creek in Westchester county; in the valley of Peekskill creek, near the east line of Phillips-town and west lines of Carmel and Kent in Putnam county; and on the shore of the Hudson, at the limestone quarries between Caldwell's landing and Stony point.

Local Details.

In Washington county, the talcose and chloritic slates were observed between Whitehall and Hampton villages. They were most distinctly characterized near the anticlinal axis, in the eastern part of the town of Whitehall and west part of Hampton. The limestones and calciferous rocks to the west of this axis do not seem to have been as much changed in aspect by the metamorphic agency, as the slate rocks along the axis, and east of it for one or two miles. The strike of the strata between Hampton and Whitehall is about N. 20° W. The position of the rocks is believed to be correctly represented on Plate 28, fig. 1.

(A.) Primary rocks (gneiss, granite, hornblende, etc.)
(B.) Potsdam sandstone.
(C.) Calciferous sandstone, Mohawk limestone, etc., lying in successive steps, caused by faults nearly parallel to the strike of the strata.
(T.) The quaternary deposits of the valleys.
(X.) The slate rocks of Champlain division, changed by metamorphic agency along the axis into talcose and chloritic slates.

The Potsdam sandstone does not show itself on this line of section, except near Whitehall, but it is very much indurated next the gneiss rocks; and in some places on the shore of Lake Champlain, within a mile of Whitehall, it seems to have been changed to a gneiss rock, or rather a stratified silico-felspathic rock like gneiss, only it is entirely destitute of mica.

In Putnam, about half a mile west of the ferry across Lake Champlain, is a rock that appears to have once been the Potsdam sandstone, but is now a rock approaching in character to gneiss. It contains distinct small pebbles of white and grey quartz, like some of the lower beds of the Potsdam sandstone. The rock is nearly horizontal, and dips slightly to the west-northwest, with a steep escarpment on the east showing the layers of the rock. The primary, gneiss and hornblendic rocks between there and the lake dip at a high angle.

In the northeast part of Granville, the strata of the slate were talcose and chloritic, and traversed by many quartz veins.

At the falls of Pawlet river near North-Granville, the rocks also belong to the Taconic system. The rocks of this system range continuously from Granville through the eastern parts of Hebron, Salem and Whitecreek. They present all the varieties of appearance that are observed in the rocks of the system. The slate is sometimes the same as the slates described

in the Hudson-river and Utica slate groups and the argillite, and these are often traversed by veins of quartz in every direction; red slate, red and green mottled slate, and red jaspery slate also occur. Talcose slate or talco-argillaceous slate is most common, and chloritic or argillo-chloritic slate is not rare.

A little farther to the west, the limestones, calciferous sandstones, and slaty limestones interstratified with the slates, appear and range parallel to the slates in parallel broken ridges that have no apparent connection, until their localities are marked on the map. Nearly all the township of Whitecreek is occupied by the Taconic rocks. They range along the west side of the Owlkill valley, north and south of Cambridge. The limestone, slate, talcy slate, and calciferous rocks form several parallel belts in this township, but none of the limestone assumes the character of a white crystalline limestone until beyond the line of New-York in the State of Vermont. A mile or two east of the State line, it is quarried for marble. It rarely acquires this character west of the talcose and chloritic limestone, except where the rocks are penetrated by trappean and granitic veins; but almost all of the limestones east of the belt of talcose slate, except that near Whitehall, is converted into a white or grey crystalline and dolomitic limestone, from Vermont to the Hudson river or Long-island sound. These and other highly altered rocks will be described as metamorphic rocks.

In Rensselaer county, the talcose and chloritic rocks, and the limestones variously modified by metamorphic agency, may be seen along the banks of the Hoosick river, between the mouth of the Little Hoosick and the Vermont line, and thence on towards Williamstown. The river here crosses the Taconic mountain through a gorge, and the transverse section exhibits the nature and position of the strata. In some localities the limestone is a white, crystalline, granular, dolomitic rock; in others it is scarcely altered from the calciferous rocks, and the compact and sparry blue limestones. The slate is in some places like argillaceous slate and roof slate; in others it is highly talcose or chloritic, and the red slate is also quite common.

Rocks of the same character, but less altered, the limestones being sparry, and the slates less talcose and chloritic, range along the western side and through the valley of the Little Hoosick in Petersburgh and Berlin.

The Taconic mountain extends south through the east parts of Petersburgh, Berlin and Stephentown, into Columbia county, and it occupies a variable breadth also in the towns of Williamstown and Hancock in Massachusetts. It contains the same kinds of rocks as those described in the gorge through which the Hoosick crosses the Taconic mountain. The surface in very many places is strewed with boulders and loose fragments of milky quartz, much of which contains abundance of chlorite, in nests and in cavities in the rock. The chlorite is in small aggregated green scales. These loose masses of quartz are derived from the decomposition, disintegration and washing away of the slate rocks, in which they constituted parts of veins and nests; and as the quartz withstands atmospheric agents and abrasion better than the slate, great quantities of it are found on and in the soil near to where it abounds in the slate rocks.

Prof. Dewey described these rocks between Williamstown and Troy in 1820. Speaking of the rocks of the Taconic range in Williamstown, he says: "It will be recollected that the rocks of the Taconic range in this town were stated to be argillaceous slate, chlorite slate, and talcose slate. The last predominates, and abounds on the descent of the range into the valley of Petersburgh. This valley, of variable breadth, extends several miles north and south, and is traversed by a stream which runs northward into Hoosick river. In this valley is found abundantly the same mixture of chlorite and quartz which is so common in Williamstown, though the two valleys are separated by the Taconic range having an elevation of one thousand to one thousand four hundred feet." "On the west side of this valley, and about seventeen miles east of Troy, lies *chlorite slate*, very distinctly characterized. It is sometimes narrow, and sometimes two or three miles in width, often rising into hills two hundred or three hundred feet high."*

Much of the slate called *talcose slate*, is not the talcose slate composed of quartz and talc described by some authors, but its composition would be expressed generally by *talco-argillaceous slate*, and in some places by *talco-micaceous slate*.

The slate rocks are talcy, and associated with red, green and chloritic slates on the hills east of Tuckawassick kill in the northeast part of Nassau and southwest part of Berlin. The same may be seen south of Nassau.

In Columbia county, the Taconic rocks occupy almost the whole of the eastern line of the county between Massachusetts and New-York. A mountain range of these rocks occupies the eastern part of New-Lebanon, Canaan, Austerlitz, Hillsdale, Copake and Ancram. Several gorges cross these mountains, the principal of which are, 1st, that through which the railroad from Boston to Albany passes, south of Whiting's pond in Canaan; 2d, in the south part of Canaan, called Canaan gap; 3d, that of Green river, which extends west through Austerlitz; 4th, that in Ancram and Northeast, between Winchell's mountain and Mount Washington.

The Taconic rocks in Columbia county will be more particularly described near Lebanon springs; near the route of the Albany and Stockbridge railroad; near the Boston and Albany turnpike, and the Hudson and Hartford or Columbia turnpike; since they are near great thoroughfares, and consequently easy of access.

The rock at Lebanon springs is a slaty limestone, with talc between its layers; and a careless observer might, by very casual observation, call it talcose slate. This limestone is greyish, and is underlaid a little farther north by bluish compact and sparry limestone. The dip is about thirty degrees to the eastward, and the strike is N. 30° or 40° E. Talcy slate succeeds the limestone a few rods east of the springs, on the Pittsfield road. In the first and second ravine east of the springs, the rock is seen in place, dipping eastwardly at an angle of forty to sixty degrees. A fault of the strata is believed to have been observed near the springs, but it was not traced out. Talcy slate is visible *in situ*, at short intervals from the springs to

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* Prof. Dewey's Geological section: American Journal of Science, Vol. 2, p. 240; and he gave a more detailed account of Western Massachusetts in Vol. 8.

the summit of the mountain over which the road to Pittsfield passes. Pyrites, crystallized in cubes, are not uncommon in the talcy slate. Quartz also abounds, and this contains much pyrites, either pure or partially decomposed, and resembles in some degree the gold ores of North-Carolina and Virginia. The quartz does not seem to form regular veins, but is disseminated in masses and nests through the rock. Some of the talcy slate contains plumbago so abundantly as a coloring material, that it will mark like black-lead. The slate is variable in its aspect, but is all unctuous and variously colored, bluish, brown, black, green and red. The rocks, from the springs to the summit of the mountain, all dip to the eastward at a high angle.

About one and a half miles north of the springs, a locality of talcose rock, interlaminated with limestone, was examined. The talcose rock abounded in pyrites, and these were undergoing constant decomposition, forming sulphate of iron and of lime, and the rocks were covered with a reddish and yellowish incrustation. The earth from this place has been used in the vicinity for dyeing. An excavation had been made here, probably in search of the precious metals. The undecomposed talcy rock was filled with cubic cavities, in which crystals of pyrites had once been imbedded. Limestone was observed in abundance lower down the hill to the west, and was supposed to underlie the talcy slate and limestone. Farther south towards the springs, the same limestone was observed; and on the top of the hill, the talcose slaty limestone like that at the springs. Both dip to the eastward. The order of superposition, as near as was ascertained, was as follows:

1. Talcy slate of Hancock mountain.
2. Talcy slaty limestone like that at the springs.
3. Talcy slate and limestone.
4. Blue and grey limestones, down to the valley.

Between the springs and the Shaker village, the rock, where seen in place, was the grey limestone, more or less intersected by veins of quartz; and between that village and New-Lebanon village, the same rock was observed.

Limestone skirts the Lebanon valley, two and a half miles south from the springs on its west side. At that distance, the alluvial and quaternary deposits of the valley cease, and the stream from the south flows over a steep escarpment of the grey limestone, which is frequently highly impregnated with chlorite. The limestone here occupies the whole breadth of the valley, from the West mountain to the east or Hancock mountain, but retains the same easterly dip.

Not far south of this point is Whiting's pond, a fine sheet of pure deep water. At its outlet, blue, red and purple slates were seen, some of them much contorted, and all of them were more or less talcy, and unctuous to the touch. The valley of the outlet cuts down through all the ranges of hills to the west; and a gorge is also seen across Hancock mountain to the east, so that this transverse valley is nearly parallel to that of Lebanon creek; and a dislocation of the strata at this place, where a fracture of the mountain seems to have been made, is probable.

Figs. 4 and 5 of Plate 13, illustrate the position of the rocks in the Lebanon valley, between Canaan mountain on the west, and Hancock mountain on the east.

Prof. Barnes described the geology of this region many years ago;* and while many things are well described, he seems to have been led into a grave error in the position of the strata of Canaan mountain, which are represented as horizontal. He says, "The lower stratum of limestone described in the section is at the same height on both sides of the Canaan mountain. It is associated with slate. This limestone, part of which is siliceous, is found with slate on the top of Hancock mountain. It was also observed on the top of a mountain in Lee, fifteen miles southeast of our section. These two strata, associated on the *top* of Hancock, and at the *base* of Canaan mountain, may perhaps without impropriety be considered as parts of the same original bed."† "That the strata have dropped *in situ*, and not bent downwards as Prof. Eaton supposes, appears from the *horizontal* position of the great masses of mountain strata in our section, and also from the fact that the slate is found at the same height on all the circumambient hills, and the limestone at the same depth in all the circumjacent valleys, and the greywacke at the same elevation upon the neighboring mountains. This last rock is, moreover, *laid bare* to a great extent in that part of the mountain which lies south of the High knob. Here the whole formation is perfectly open to inspection. The upper surface is horizontal. This surface is composed of the upper edges, termed in geology the outgoings of the strata; for it must be carefully observed, that although the rocks are stratified, and the strata highly inclined, yet the great beds or mountain masses are disposed above each other horizontally, and these beds or masses are termed *strata* when in general we speak of geognostic relations."‡ The last sentence explains the cause of his error. The strata are all highly inclined, dipping to the eastward, and are entirely distinct from laminations of slaty cleavage.

Prof. Briggs, one of the assistants on the geological survey, describes the top of Canaan mountain as composed of a rock more than usually siliceous. He travelled in a zigzag direction many times across the mountain, and found it as described by Prof. Barnes, composed of limestone, slate and siliceous rocks. The limestone flanks it on each side, and ranges along its base parallel to its length, and dips to the eastward at a high angle.

The limestone in the Lebanon valley is frequently interrupted by faults. But few were traced out.§ Prof. Briggs examined the limestone near Lebanon springs with care; and speaking of that on the east side of the Lebanon valley, north of the springs, southeast of Mr. Locket's, he says, "It is thirty or forty rods in length, and appears to be a ledge of the sparry limerock imbedded in the slate, and conformable to its laminar divisions, which appear to dip S. 60° E. At the southwest part of the ledge, where it is about eighty-one paces wide, the limestone appears in some places to be interlaminated with the slate. On both sides

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* American Journal of Science, Vol. 5, p. 8 to 21. † Ibid. p. 16. ‡ Ibid. p. 16.

§ The reader undoubtedly already understands, that in consequence of the limited time for the geological survey, the great area to be examined, all of which must come under the eye of the geologists, and the time requiring sixteen square miles to be examined on an average during each working day by each of the geologists, little time could be spent in minute investigations. The outlines are marked out, and most of the filling up of the picture must be done by others.

of the ledge, and nearly its whole length, the line of junction of this rock with the slate can be most perfectly traced; but at the north end it appears to terminate abruptly against the slate, and in some places has the appearance of having been deposited on the top of its laminar edges. From the manner of termination, the appearance of slate in the vicinity, and the occurrence of a small valley a little north and transverse to the direction of the strata, I was induced to suspect the presence of a fault, and that the limerock might again be found on the opposite side of the valley, unless the dislocation had been very great." "Having ascended the acclivity to the north, I found again the same stratum of rock imbedded in slate, and pursuing the same direction. I traced it north a little distance beyond the line of Stephentown. The general character of the slate in which the limestone is imbedded is distinctly talcose; and on the east face of the ledge, where I first observed that stratum, is a locality of what Prof. Eaton has described as alum slate, where the rock is falling to pieces by the decomposition of iron pyrites."*

At Lebanon springs, the *contact* of the slate and limestone was not seen; but a few rods southeast of the springs, Mr. Briggs saw it within a few feet of their junction. Some of the slaty variety of the limestone is so much intersected with fissures, that the slaty character is scarcely discernible.

A stratum of sparry limestone was seen by Mr. Briggs on the East mountain in Canaan, between the Shaker village and the line of Massachusetts, imbedded in slate, and in some places interlaminated with it. "The slate in which the limestone is imbedded is rather talcy, and easily falls to pieces. The slate, at a little distance on either side of the limestone, is of a much coarser and stronger texture, and not so easily affected by atmospheric agents; so that the limerock and the soft slate form a kind of valley parallel to the general direction of the mountain range."† "A little south of the south Shaker village in New-Lebanon, is a ledge of the slaty kind of sparry limestone, imbedded in a very talcy kind of slate dipping east-southeast about sixty degrees. A few rods east of this place, the slate is coarser, and distinctly chloritic. The limestone has been quarried for burning into lime by the Shakers, and can be traced about thirty rods."‡ The position of the rocks of this valley can be seen in the sections, Pl. 13, figs. 4, 5.

A quarry has been opened in the slate, southeast of the south Shaker village in Canaan. The rock splits out in broad plates suitable for flagging. It is talcose, but the talc is mostly between the layers.

The limestone is seen in small knobs, one-half or three-quarters of a mile southeast of Hatch's tavern, and the contact with the slate may almost be seen. A section across the valley from the East mountain (or Hancock mountain) to the flour mill on the outlet of Whiting's pond, shows the following rocks. They crop out through the alluvial, drift and quaternary, so that the order of superposition is not seen, and they dip to the E.S.E. 40 to 65°.

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* Geological Notes of the New-York Survey, Vol. 2, pp. 341, 345.

† Manuscript Geological Notes of the New-York Survey, Vol. 2, p. 348. ‡ Ibid. p. 354.

1. Slate of East mountain.
2. Limestone at west base of East mountain.
3. Limestone ridge.
4. Ditto ditto.
5. Slate, talcy; some places red.
6. Slate of West mountain or Canaan mountain.
7. Limestone } in contact.
8. Slate }
9. Siliceous rock, slaty.
10. State } in contact.
11. Limestone }

The limestone on the east side of the valley seems to range north between the east and west mountains, through the valley towards New-Lebanon springs; "while the limerock on the west part of this valley passes through a valley on the west side of the West mountain, nearly parallel to the Lebanon valley."*

"A dislocation, and probably more than one, appears to have taken place in the limestone near the line between the land of the Shaker family and Mr. E. Tilden. The limestone here appears to have been carried forcibly towards the west, so as partially to dislocate the slate mountain, against which it rests. On a low point of Canaan mountain to the northwest, the strike of the rocks appears to be more nearly east and west than elsewhere. Near the division line before mentioned, the slate appears to abut against the limestone."†

"On the road between Canaan four corners and Lebanon meeting-house, the limestone was seen nearly in contact with the slate, on the land of Deacon Skinner. Its strike is nearly northeast and southwest, and disappears in the latter direction near the land of Mr. Carpenter; but if the strike be continued in a southwest course, it would run across the valley, and intersect the slate hills on the west side. This (disappearance?) can only be accounted for by a dislocation at this place, which is probable, as there is a notch in the mountain opposite."‡

Most of this range of limestone, from Stephentown through New-Lebanon and Canaan, is a very rough looking rock, traversed by veins of quartz in every direction; and where exposed to the weather, the carbonate of lime has been removed to some little depth, and left the quartz veins projecting from the surface of the rock. The limestone ridges south of Whiting's pond show this character well at the lead mines, that were formerly opened and have since been abandoned, and where the Albany and Stockbridge railroad intersects them. They are here broken into huge masses by *joints*, and the fractures caused by the upturning and overturning agency that placed the strata in their present position.

The country between the two main branches of Claverack creek in Ghent, Hillsdale and Claverack, is very broken and hilly, composed mostly of slate rock which is highly talcose in many places. It passes into the argillaceous slates on the west. Grit rocks are interposed in

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* Mr. Briggs' MSS. Geological Notes of the New-York Geological Survey, Vol. 2, p. 359. † Ibid. p. 371. ‡ Ibid. p. 396.

many places, like the Hudson-river group. On the Columbia turnpike from Hudson to Hillsdale, the slate, near the line between Claverack and Hillsdale, shows veins of the milky quartz in abundance; and these veins contain chlorite, pyrites and brown spar, like the similar rocks in the western parts of Austerlitz, Canaan, New-Lebanon, and eastern parts of Ghent and Chatham. Farther east, the rocks become more talcose, and contain crystals of pyrites. They all dip to the eastward at high angles. Limestone, like that of the Lebanon and Little Hoosick valleys, was seen on the east side of Ancram creek in Hillsdale, about a mile east of the village, at the base of the mountain. It was succeeded on the east by talcy slate, which continued to the summit of the mountain. Diluvial scratches were seen in abundance on this road near the line between New-York and Massachusetts, near an angle of the valley up which the road passes, about two hundred feet above its bottom, on a point of the lower range of mountains. The rock on the north side of the road is ground off over a large area that is exposed. Their direction is N. 55° W. and S. 55° E. The rock is the talcy slate, with veins and nests of quartz containing pyrites, brown spar, and oxides of iron and manganese. The quartz resembles that from some of the gold mining districts of North-Carolina and Virginia.

The position of the rocks, and their succession, are represented on the section from Hillsdale to Little-York in Massachusetts (Vide Plate 14, fig. 1). Sections across similar rocks in Columbia county are represented on Plate 14, figures 2, 3, 6; Plate 13, figs. 3 and 6; Plate 16, figs. 1, 3; Plate 17, figs. 1, 2, 3. The same order of succession as that indicated on Plate 14, fig. 1, was observed in crossing west over the mountain from Little-York, four or five miles north of the line of section. At the western base of the mountain in the Ancram creek valley in Hillsdale, fine quarries of white and clouded grey marbles may probably be opened. On Mr. William Palmer's land, the white limestone is deemed to be of good quality, but is not favorably situated for working extensively, in consequence of its lying so low. The localities where where the limestone is *white* and *highly crystalline*, are not very numerous in this valley; and this is mentioned *here*, only as affording the means of tracing its connection with beds of the same rocks less changed by metamorphic agency. On the east side of this mountain range the white limestone abounds, and is extensively quarried for white marble in Egremont, Sheffield, West-Stockbridge, &c. On the east side of the mountain between Little-York in Egremont, and William Palmer's in Hillsdale, the grey limestone (which is the same as the white, only less altered) was observed interstratified with the slate. About one mile from Hillsdale village, on the road to Green river in Austerlitz, limestone was seen in place on the banks of the west branch of the creek, and it continued in place at intervals to near the church, four or five miles north of Hillsdale. At one and a half miles on the east side of the road, across a bog of ligneous peat, the limestone crops out in a knoll, and is filled with cubic crystals of iron pyrites. The rocks, from the church above alluded to, when seen, were slate, talcy slate, and chloritic slate, with some grits, to Canaan gap, where the Albany and Boston turnpike and the railroad cross through the mountains. Limestone skirts the east side of the valley leading north into the Lebanon valley, of which it is a part. It is grey or light buff-colored, and more or less intersected by veins of calc spar and of quartz. The lime-

stone continued ranging northward to within a short distance of the outlet of Whiting's pond, where it was succeeded by the slate as described in a preceding page.

The rock, from Canaan four corners to Canaan centre, is slate, which is highly talcose in some places. At Canaan centre, east from the tavern, is a bed of limestone, which is traversed by veins of carbonate of lime and quartz. The cut of the railroad a quarter to half a mile south of Canaan centre, exposes a beautiful section of the slate rocks, of purplish and grey colors. Quartz veins penetrate the rock in every direction, without any of that regularity that is usually expected to be seen in *veins*. The quartz contains brown spar; and where this has decomposed, an earthy oxide of manganese remains, and sometimes it shows traces of the original crystalline texture of the mineral.* The occurrence of this mineral in some quantity in the rocks of this region, and its easy decomposition, will, perhaps, account for the abundance of wad, or earthy oxide of manganese, observed in this region, and described among the alluvial depositions on page 121 of this volume.

About half a mile south of Canaan centre, a ridge of siliceous rock, perfectly injected with quartz, permeating every part of the mass, crosses the strata from northwest to southeast. It is four to six rods wide on the surface, and analogous to much of the rock in the hills south of it, and also to the boulders in the northeast part of Chatham and northwest part of New-Lebanon, and the ridge above Rider's mills.

The rocks down the valley of Green river, between Austerlitz and Green-river village, are talcy slate on the right bank. The mountains on the left bank abut in echelon upon the valley of Green river.

The limestone in the Copake valley, north of Hillsdale, between —— mills and the Baptist church, ranges northwest and southeast.

South from Hillsdale, Messrs. Merrick and Cassels traced the grey and bluish limestone from near the gate on the Columbia turnpike, east of Hillsdale, to Copake meeting-house. In one place on that road, two miles south of the gate, it rises in a perpendicular ledge about thirty feet. Near this place the road is cut through the limestone, which is slaty, and somewhat similar in character to that at the outlet of Whiting's pond. The strike is south-southeast. North of Copake, in the fork of the roads, is a small hill, called Mount Tom, the base of which is slate, but the top and southeast side are of slaty blue limestone dipping to the east like the slate. In many places in this vicinity, the rock is the *sparry limerock*, checkered with the veins of calc spar and quartz.

At Griffin's mills in Copake, on the west side of Copake flats, the limestone was observed by Prof. Cassels, who traced it along the eastern base of the mountain on the western side of the Ancram valley, about two and a half miles to the northward, where he left off tracing it, to examine the slate of the mountain, along the base of which the limestone ranges. These rocks were seen nearly in contact, both dipping highly to the east, and the slate apparently

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* This mineral has, I suppose, been analyzed by Prof. Beck, the Mineralogist of the Survey. It evidently contains more manganese than any of the ordinary varieties of brown spar; but as this is isomorphous with iron, it may combine by replacement to any extent.

pitches under the limestone. Some of the slate is talcy. The continuation of this range of limestone forms the east base of the mountain northwest of Hillsdale village, where the same slate rock is also associated (the roof slate), and apparently pitches under it, both dipping to the east. The limestone is granular and grey.

Prof. Merrick examined a locality of pyritous copper ore on Mr. John S. Collins's farm. There was little ore, but the locality showed a bed of "quartz and feldspar" in the limestone. Mr. C. assured Prof. Merrick that a rumbling noise under ground was frequently heard in the vicinity of the "mine," just before a storm, and that the ground was often so much agitated as to cause a rattling of the windows!

Prof. Merrick found a large mass of quartz, similar to that of the flat veins between the strata, northwest of Hillsdale. It was several feet wide, and was visible for some distance on the surface.

Dutchess County.

A mountain mass of the Taconic rocks ranges through Ancram, the east part of Pineplains, the west part of Northeast, and northwest part of Amenia.* The northern part in Ancram is called Winchell's mountain. It is composed of slate, talcy slate and chloritic slate, and is intersected by numerous veins of quartz. Limestone ranges along the base of the mountain on both sides. It is generally grey and blue, though in some places at the eastern base of the mountain it is white.

Local details on this mass. About one and a half miles northwest from the gate, which is on the mountain west of Amenia, the slate is chloritic, and is soon succeeded, as we pass towards the "city,"† by talcose slate. A short distance north of the "city," the rocks are much broken up, and are talcy slate and talcy limestone, and both rocks contain cubic crystals of iron pyrites. The bluish grey and clouded limestone soon succeeds on the west, apparently pitching under the talc slate. In some places this limestone was checkered by veins of carbonate of lime and of quartz. Limestone was the rock seen in place from thence to Pineplains, except at a place where the road crosses a small stream about half or three quarters of a mile east of the Quaker meeting-house, and here the *slate* was the rock seen in place.

The country between Ancram furnace and the base of Winchell's mountain consists mostly of limestone, frequently alternating with the slate. The strata are very much deranged, broken and contorted. The slate is argillaceous, talco-argillaceous, and like roof slate, and in some places intersected and shivered by joints into such small masses as to be called

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* It is to be observed that the different ranges of rock do not conform to the ranges of hills and mountains, but cross them obliquely. This instance is one of the examples. The range of mountains which extends from Beekman to Ancram, terminating near Boston corners in Winchell's mountain, is formed in its northern part of slate, and talcose and chloritic slates; the middle part, of mica slate; and the southern portion, of gneiss.

† The "city" is a small village in the northwest part of Amenia.

columnar slate, the columns being from half an inch to two or three inches in diameter. A locality of this is about one mile northwest of the Livingston lead mine, on the road side. Some of the slate is black with carbon (graphic slate), and in places plumbaginous. The limestone is grey and subgranular; blue and compact; and sparry. It is an extension of the same range described in Copake, and was traced continuously into Pineplains in Dutchess county, and observed to alternate apparently with the slate.

A little to the east of Crysler's pond in Copake, grit rock was observed in nearly horizontal layers dipping slightly to the east, and was immediately succeeded on the east by blue limestone like that near Ancram furnace; and this underlies most of the valley east to Copake, cropping out occasionally through the quaternary of this valley. The limestone of Tom's hill has already been described. Slate succeeds the limestone on the east, and that again is succeeded by the grey and bluish limestone between Tom's hill and the Copake ore bed. Mica slate (containing garnets and magnetic oxide of iron), and talcose slate, form the western base of Mount Washington, between the Copake ore bed and Taghkanic falls. The dip of all of these strata is at a high angle to the east-southeast.

About one-quarter of a mile south of Copake, the junction of the limestone and slate like those of Tom's hill and east of it, was seen; and soon after, on the road to Boston corners, a small ridge of limestone, like that between Tom's hill and the Copake ore bed, was crossed. The limestone continued to be seen in place occasionally to Boston corners, and thence south-southwest to the base of Winchell's mountain, and seemed to skirt its eastern base, as loose masses were abundant on the surface, but the rock was not seen in place. Winchell's mountain, which we crossed about two miles southwest of Boston corners, is composed in this place of slate rocks, some of which are like the roofing slate of the mountains from Copake lake to Hillsdale, and some is talcy, and forms the top and west side of the mountain. Limestone succeeds the slate at the western base of the mountain, apparently pitching under it, and forms the valley southwest to the Hot ground* at Punch brook, by the Livingston lead mine, where it is succeeded by the slate; and these rocks alternate, or longitudinal faults cause the appearance of alternation, between that place and Chicomeco creek. Still farther towards Pineplains, the limestone is observed resting on gneiss, where both crop out through the quaternary. The limestone along the eastern side of the Ancram creek valley, from Hillsdale to Copake, seems to range down the valley east of Winchell's mountain; while that of the western side of the valley spreads out in Copake and Ancram, ranging south on the west of Winchell's mountain, and alternating or apparently alternating with the slate.†

On the route from Amenia, through the central and western parts of Northeast, towards Pineplains, Prof. Merrick observed masses of talcose slate firmly adhering to the limestone, but in no case penetrating it; and talcose slate a little farther west, dipping so as apparently,

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* The name "*Hot ground*" need not be understood as having any *geological* meaning. It is said to have been a place of much dissipation; and before the time of the temperance reform, is said to have been celebrated for its *flip* and *hot whiskey punch*.

† It is supposed that the *alternation* of the main masses is not *real*, but merely *apparent*, caused by longitudinal fractures and faults of the strata, so that they lie in successive steps, as is represented in Pl. 7, fig. 4; Pl. 8, figs. 1, 2, 3, 8, 9; Pl. 25, fig. 2.

but not really, to plunge under the limestone. This locality is on Mr. Worster Wheeler's farm, about one and a half miles southeast of the village of Northeast. The limestone is a grey variegated granular limestone, that would make a beautiful clouded marble. About one mile northwest of Mr. Wheeler's, well characterized mica slate was observed in the hill on the east, and talco-argillaceous slate on the west side of the road. About half a mile farther west, he observed a ridge of limestone dipping to the west.*

About one and a half miles northwest of Northeast village, near a small stream, the talcose slate and limestone were observed to alternate twice. The actual junction, where the rocks were firmly cemented together, was observed in one place. A similar junction of the talcose slate and limestone was observed in Northeast, where the road crosses the outlet of Indian pond.

A few rods east and southeast of the Amenia ore bed, the slaty limestone is seen superposed on the talcy slate, as is represented on Plate 23, fig. 2, at (*d*) and (*e*).

On the summit of the mountain in Northeast, where the Sharon road intersects that from Amenia to Pineplains, the rock is slightly talcy. Soon after leaving the base of the mountain, the limestone was observed to be abundant. On the eastern side of the mountain, it alternates with the slate, which is variable in character, in some places being talcy, in others like roof slate.

Nearly opposite the Episcopal church, half a mile north of Lithgow post-office in Washington, the sparry limestone was observed several rods in width, dipping to the east, and ranging S. 30° W. At the "City," in the northwest part of Amenia, the rock is talco-argillaceous slate; and about one hundred rods to the west of this place is an old mine hole, reputed to be a copper mine; but Prof. Cassels reported, that the copper ore, if any had been obtained there, must have been in very small quantity. The excavation is in the talco-argillaceous slate, traversed by veins of milky quartz.

Pineplains is situated on the quaternary, and underlaid by the slate rocks; but the sparry limestone forms a ridge called Mill hill, a little east of the village; and this rock is the prevailing one, alternating, however, with slate, for three to three and a half miles east towards the Salisbury ore bed. It is succeeded by the slate of Winchell's mountain, which is talco-argillaceous, and in some places micaceous. This mountain separates Pineplains on the east from the township of Northeast. A stream sinks in the limestone near the junction of these rocks, and has been already described on p. 112 of this volume. The slate dips to the east at a high angle. Limestone succeeds the slate for a short distance a little east of Pulver's corners, and alternates several times between that place and the Salisbury ore bed; but the most important are at Spencer's corners, and at the brook by the line between New-York and Connecticut, on the turnpike. The slate of Winchell's mountain is very fissile, talcy, micaceous and argillaceous, frequently colored, and more or less loaded with plumbago.

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* It is to be understood, that where the dip is not mentioned in describing the rocks between the Hudson and east line of New-York, it is to the eastward, generally to the east-southeast, at high angles.

The limestone about Pineplains seems to divide into two branches, one of which ranges by the south end of Mount Stessing (where it is underlaid by the Potsdam sandstone resting on gneiss), down Wappinger's creek to Barnegate, which has been described as the Barnegate limestone; the other up the valley of the Chicomeco creek, through the western part of Northeast, the western part of Amenia, the eastern part of Washington by Lithgow and Mabbitsville, and down the clove through Unionvale and Beekman into Fishkill. Another branch of this limestone ranges from Stamford through Washington to half a mile east of Verbank in Unionvale, to Poughquaick in Beekman, and thence down the Fishkill creek to Matteawan. In many places near the mica slate and gneiss of the Chesnut ridge (which is the southern extension of Winchell's mountain south towards the Highlands), and especially in the low valleys, the limestone is altered to a grey and white granular limestone more or less dolomitic, like that of the Dover and Oblong valley east of Chesnut ridge and Winchell's mountain, and like that of Berkshire county in Massachusetts, and the southwest part of Vermont.

Continuation of details of the Taconic rocks. About a quarter of a mile southeast of Pulver's corners in Pineplains, on the east side of Winchell's mountain, the junction of the slate and sparry limestone was observed. Both dipped slightly to the west, the slate being on the west side.

A quarry of talcy argillaceous slate, containing cubic cavities in which crystals of pyrites have been embedded, was seen on the east side of Winchell's mountain, about a quarter of a mile north of Pulver's corners. The rock is similar to that of Foster's slate quarries, in the west part of Hillsdale. The rock of this quarry is used for the lining of furnaces, and when laid with the edges to the inside of the stack, resists the heat almost as well as fire bricks.

The Ancram or Livingston lead mine is in the talco-argillaceous slate, a few rods from its junction with the sparry limestone, both rocks dipping to the south-southeast at a high angle (Vide Pl. 23, fig. 4).

The numerous excavations for lead and copper in southeast, were made in 1740, and during the Revolution, on the farms of Mr. Abraham Bockee and Mr. Ward Bryan. They are in the limestone, which is grey and subgranular. The talco-argillaceous slate is within a few rods to the west, and both dip at a high angle to the eastward (Vide Pl. 23, fig. 5).

Prof. Merrick observed a slaty and talcy limestone at the base of a hill a little west of the village of Separate, very similar to the rock at Lebanon springs. Talco-micaceous slate lies next on the east, and talco-argillaceous slate on the west, traversed by veins of quartz. The fragments of quartz are very much scattered over the surface. The talco-argillaceous slate becomes less talcy on the west, and forms the range of hills in the east part of Stanford, and the rock is very much contorted.

A few rods west of Thompson's pond, he observed limestone that he thinks would make a fine clouded marble, but only a small area of the rock was exposed.

The granular quartz rock at the southwest end of Mount Stessing in Pineplains and Stanford, already described as the Potsdam sandstone, may, from its modified character, be considered as belonging to the Taconic rocks. It is nearly horizontal in position, reposing on

gneiss at the base of Mount Stessing, and is overlaid by the Barnegate limestone, and that by the slate rocks of the west side of the mountain. It resembles gneiss at a little distance, but is a hard, close-grained, siliceous grit rock. Another mass of this rock was mentioned by Mr. Walter Reynolds of Pineplains, and said to cross the limestone ridge obliquely, a short distance southeast of Pineplains.

The ridge dividing Washington and Pleasant-valley has breccia and sparry limestone on its western base, and red slate a little farther to the west, and ranges south into Lagrange. Talcy slate was also observed by Prof. Merrick a little east of Verbank in Unionvale, and he considers it as being an extension of that observed in the southeast corner of Stanford; also sparry limestone half a mile east of Mabbitsville, and talcy slate two and a half miles east of the same village.

The slate in the ridges passing through the eastern part of Stanford, the middle and western parts of Washington, and along the line between Unionvale and Lagrange, is very much traversed and intersected by viens of quartz, and is contorted. The outcropping edges are waving. Extensive excavations are said to have been made in these rocks in the northeast part of Lagrange, about sixty years ago, in search of silver; and although there are marvellous reports of the quantities obtained, no traces of any metal were observed but pyrites.

Talcy limestone was observed in place about a quarter of a mile west of Hopewell. White limestone, that would make a good marble, was seen about one mile west of Poughquaick. Limestone is the most common rock seen emerging through the extensive quaternary plains of Fishkill, and in many places it assumes the aspect of what we have been in the habit of calling *primitive limestone;* but which is the same as that generally found in this valley, and which has now been traced in modified forms, from a compact and sandy limestone to a white marble, from Vermont to the Highlands.

About one mile and a half above Matteawan in Fishkill, near the creek, the limestone seemed to repose on the granite rock. The limestone was on the east side of the granite, dipping to the east; and the granite was succeeded on the west by red and green slates, that seemed to pitch under it towards the east. The direction of the granite and associated rocks was parallel to the creek for some distance, forming a low ridge, which finally crosses the stream about a quarter of a mile from the bridge. The strike is N. 50° E. The red and green slates are red and green in the same continuous layers, and the colors are probably due to the different degrees of oxidation of iron in the different parts of the rock. Near Matteawan, also, the granite, and red, green and black slates were observed.

About one mile east of Stormville in Fishkill, the limestone of the Fishkill valley is succeeded by the granite and gneissoid rocks of the Highlands. Patches of limestone, however, like that of the valley, were occasionally seen on the mountains farther east. The dip of these primary rocks was 60° to 80° eastwardly, and the strike N. 45° to 60° E.

Altered slate rocks, that may be classed with the Taconic rocks, occur about four miles north of Newburgh, near a small hill of granite rock.

The limestone of Monroe, between the Highlands and Goosepond mountain, and about Bellevale and Warwick, may also be considered as belonging to the Taconic rocks, as they do in

some places rest on the primary, and are slightly altered and contain crystals of the oxide of titanium.

Theoretical Considerations on the Taconic System.

It will be observed by those who have read the preceding details in regard to the Champlain division, and the Taconic system, that they *are considered to be the same rocks, the latter somewhat modified in character by metamorphic agency.* This conclusion rests upon the following trains of evidence:

1. They are each composed of three principal masses of strata, in the same order of superposition, viz:

{ Slate rocks;
Limestones;
Hard sandstone.

2. Wherever we can trace the order of superposition of these rocks with Primary rocks, both the Champlain division and the Taconic system rest upon them, without any interposed strata.

3. We have traced the changes of the slate into talco-argillaceous slate and talcy slate through all its gradations, and when carbonaceous, into graphic and plumbaginous slate; the limestone, from compact, sandy and slaty, to checkered or sparry limestone, slaty talcose limestone, and granular crystalline limestones in the same continuous beds, and within short distances; and the Potsdam sandstone, to a hard, compact and granular quartz rock.

4. The localities where these changes are most marked, are situated along lines of upheaving and disturbing action, and where the strata have been most exposed to the influence of intrusive or plutonic rocks.

These rocks, in their extremes, vary so much, that it requires very strong evidence to convince the mind that the rocks of the Taconic mountain range, along the line between New-York and Vermont and Massachusetts, are of the same geological age as those of the Mohawk valley; but I think that those who will carefully and dispassionately examine the subject, and who are qualified by experience to examine a district where the geology is so extremely complicated, will arrive at that conclusion.

The facts that have been detailed have not sufficient connection, and the relations of the particular strata and their extension have not been traced out with the care that was desirable, to give such evidence as to carry *conviction* to every mind.

The faults and transverse heaves of the strata, and a great number of interesting classes of facts that it was desirable to investigate, could not be minutely studied, in consequence of the necessity of travelling rapidly over the country, to examine the whole territory in the time prescribed by law; and the facts that *have been obtained*, were gleaned when thus engaged.

Though the facts stated may be insufficient to convince all, they, together with a multitude of others observed, but not noted in the manuscripts of the survey, have left a conviction on *my* mind, that the *Taconic rocks are the same in age as those of the Champlain division, but modified by metamorphic agency and the intrusion of plutonic rocks.*

CHAPTER VIII.

METAMORPHIC ROCKS, AND THEIR CONTENTS.

INTRODUCTORY REMARKS.

Under this head, it is designed to describe such rocks of the First geological district as have not yet been described, and of which there is demonstrative evidence, or such as renders it highly probable, that they were originally sedimentary rocks, but have since been altered in their character, so as to change them into such rocks as have usually been called primary. Granite, gneiss, hornblendic gneiss, sienite, and the plutonic rocks generally, are not included in this class, but will be discussed in another chapter.

In the preceding chapter, the Taconic rocks are considered as altered rocks of the Champlain division of the New-York system; but in those, the change is not so great as in the Metamorphic rocks that are now to be described, and which are considered the same, only still more altered by metamorphic agency. When describing the rocks of the Hudson valley in 1840,* I offered the opinion that those "in the eastern parts of the counties of Washington, Rensselaer and Columbia, gradually change in their aspect, becoming more shining, more talcy, chloritic and plumbaginous, more traversed by veins and nests of quartz, and assume more the aspect of metamorphic rocks. The rocks of the Hudson valley dip eastward, with a few local exceptions, at a high angle, and seem to dip under the rocks we have been accustomed to call primary; and those rocks on the eastern boundary of the valley, that from their *position* would seem to be of more recent formation, approach in characters to those called *primary*, and finally become blended with them. I feel inclined to consider them *metamorphic, with intrusive rocks interstratified.* Quartz in veins we know is found everywhere in that region, and in many places the rock is permeated by it in every part like a sponge filled with water, and it is evidently an intrusive rock. Again, the limestones are in places a crystalline, white, or clouded marble; in others a compact limestone. Again, granite and quartz veins are very common in the mica slate, and talcy mica slate, of the Green mountain range in Vermont and Massachusetts, adjoining the slate ranges of the Hudson valley. The granular quartz of Bennington (Vermont), and which occurs in Dutchess county (New-York),

* Vide Fifth Annual Geological Report of New-York, 1840, p. 93, 94.

I believe to be the Potsdam sandstone in a metamorphic form; and the granular limestones associated, to belong to the same geological epoch. I believe that time will bear me out in expressing the opinion, that the rocks from Lake Champlain along the eastern parts of the counties of Washington, Rensselaer, Columbia, Dutchess, nearly all of Putnam, Westchester, northwest part of Rockland, and southeast part of Orange, are metamorphic and intruded rocks; and I would suggest, that probably nearly all the rocks from the New-York State line east to the Connecticut valley are similar. The talcose and micaceous and talco-micaceous slates of the Green mountain range in Vermont, Massachusetts and Connecticut, have a strong analogy to the metamorphic slates of the east part of Washington, Rensselaer and Columbia counties; but are traversed by large granite veins, and interstratified with intrusive rocks which might be expected to produce a greater change in mineralogical combinations."

In expressing the above opinion, the rocks already described as the Taconic rocks were included in the Metamorphic rocks. In describing the Taconic rocks separately, I have yielded to the opinion of some of my colleagues, who have considered them as interposed between the Champlain division and the Primary. I can discover no evidence of any such interposition, but consider them as rocks modified by metamorphic agency, and intermediate in their characters between the unchanged rocks of the Champlain division, and those still more altered and crystalline along the eastern line of New-York, and in the western parts of Vermont, Massachusetts and Connecticut.

The southern extension of the Taconic rocks across the Highlands in Putnam and Rockland counties, will properly be considered when the metamorphic rocks of the Highlands and east of them shall be discussed, as some of the limestones and other rocks are more altered than those heretofore described.

The Metamorphic rocks of the First geological district may properly be divided into two general divisions, in consequence of the marked difference of the degree of metamorphic changes to which they have been subjected, viz.:

1. *Metamorphic rocks east of the Hudson, and of the Highlands.*
2. *Metamorphic rocks of the Highlands, and of Saratoga and Washington counties.*

There is a marked distinction in the characters and relations of these two classes of Metamorphic rocks.

In the first, the limestones are granular, dolomitized, and stratified; the slates are talco-argillaceous, talcose, chloritic, or micaceous slates, the latter predominating; and the sandstones are changed to granular quartz rock, eurite and gneiss.

In the second, the limestones are changed to white and sometimes red, coarse-grained crystalline limestone, containing various crystallized minerals, with scales of plumbago, and the rock rarely shows any traces of stratification; the slate is changed to mica slate, micaceous gneiss, or hornblende slate; and the quartz rock is changed so as to be scarcely recognized as such, or compact like eurite, and is supposed in some instances to have been changed into some of the anomalous aggregates observed in connection with these rocks.

In the first class, also, the intrusive rocks bear but a small proportion to the altered rocks,

and are mostly quartz and granite; but in the second class, the undoubted plutonic rocks abound, and consist of granite, sienite, greenstone, augite, serpentine, diallage, and intrusive metalliferous veins.

I. METAMORPHIC ROCKS EAST OF THE HUDSON AND HIGHLANDS.

These rocks range from Bennington and Shaftsbury in Vermont, in a direction about south through the west part of Massachusetts and Connecticut, and the eastern part of New-York, in the counties of Dutchess, Putnam, Westchester and New-York, to Long-island sound and the Hudson river.

Between the Taconic rocks as they have been described, and the Metamorphic rocks to the east of them, no well marked line of distinction can be drawn, as they blend into each other by insensible shades of difference. This is true as far as the Highlands, in and south of which, no trace of the Taconic rocks with such characters as have been described are visible in New-York.*

The Metamorphic rocks intended to be described in the first class, do not fairly make their appearance in the State of New-York north of Dutchess county. There are a few localities in Lebanon, Canaan, Austerlitz, Hillsdale, Copake and Ancram, near the line of Massachusetts, where the limestone might be referred to this class; and some few localities have been mentioned where the limestone was white and highly crystalline, while describing the *Taconic* rocks. These rocks enter the State of New-York in the northeast corner of Dutchess county, from the south end of Mount Washington, and range thence in New-York to the city of New-York.

The strata of these metamorphic rocks are very much broken, so that no stratum has been traced continuously for more than a few miles.

The *mica slate* from Mount Washington crosses the valley of Oblong creek very obliquely; also the mountain which is called Chesnut ridge, south of Amenia, and Winchell's mountain north of that place. The mica slate occupies about half the breadth of the mountain west of Amenia, on the turnpike from that place to Poughkeepsie; and it forms most of the same mountain to the Highlands, as the western boundary of the Oblong and Dover valley. On the east of this range of mica slate (which blends off on the west into talcy and talcy argillaceous slate), the rocks are almost entirely of mica slate, crystalline white and grey dolomitic limestones, and quartz rock, eastward to the gneiss rocks near the Housatonic. In some places, garnets and crystals of staurotide are found in the mica slate, but they are not common, and more frequently it shows a talco-argillaceous character, in New-York, indicative of its origin, except in the Highlands and farther south.

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* It is necessary here to except the narrow strip of the Taconic rocks that passes through the Highlands, or just on the east side of the mass of peculiar gneissoid and granitic rocks that forms the Highlands geologically, from near Shenandoah in Fishkill, to the mouth of Peekskill creek in Westchester county, and the extension of the same in Rockland county; but in some parts of this range, the rocks are so much altered, as would prevent their being recognized but for tracing them out.

Local details in Dutchess county.

Near the line between Northeast and Salisbury, the talco-micaceous slate and whitish limestone were observed; and a little farther east, the mica slate was well characterized, and contained garnets and some crystals of staurotide. The rocks dipped rapidly to the eastward.

At the Indian-pond ore bed, white and grey limestone apparently underlies, and mica slate overlies the ore (Vide Plate 23, fig. 1). These rocks dip sixty or seventy degrees to the eastward.

The mountain near and southwest of Leedsville in Amenia, is composed of mica slate and limestone, and both dip to the east at a high angle (Vide Plate 23, fig. 3; and Pl. 38, fig. 2). In the latter, the dark shaded strata are mica slate, and the light colored the limestone. The quaternary formation of the valley on the east is represented on both figures. These sections were about half a mile distant from each other. Nearly all the rock seen in place between that mountain and Amenia was limestone, always highly inclined to the east, and sometimes almost vertical. It is generally white, or grey and granular.

At the Amenia ore bed, white limestone was seen in place a few rods to the west, and talcy micaceous slate on the east, the latter overlaid by bluish and sandy limestone (Vide Plate 23, fig. 2).

At the Deep-hollow furnace, two and a half miles south of Amenia, the rock is mica slate, somewhat talcy. Limestone succeeds the mica slate on the east side of the valley opposite the furnace, and this is succeeded farther east by mica slate. These rocks form the mountain which here terminates on the south, and extends northward to a little west of Leedsville, and becomes very low to the northeast of Amenia Seminary. The limestone is quarried a little east of the furnace, for a flux in smelting the ore. The rock is white, and lies in nearly vertical strata.

Between the Deep-hollow furnace and the steel-works farther to the southeast, the rock is mica slate, and is succeeded on the east by the white and grey granular limestone.

The limestone was seen in place from near Kline's corners (a small village in the southeast part of Amenia), to Hitchcock's corners, (another small village on the east line of Amenia), and thence at frequent intervals to Leedsville. Much of this rock is very white and very massive, and could probably be quarried for the same kind of marble that is so extensively wrought in Berkshire county in Massachusetts, and Litchfield county in Connecticut.

There seem to be two main ranges of the white limestone in the valley east of the Chesnut ridge. One ranges down the west branch of the valley from northeast by Amenia Seminary and Deep-hollow furnace; thence south to two miles north of Dover plains; thence by Dover plains, cropping out at intervals in low ridges and hummocks through the quaternary of the Dover valley; the other ranges down the Oblong valley in Sharon and Amenia by Leedsville, Hitchcock's corners, Kline's corners, and the hills a little east of Dover, where it crops out also in low ridges through the quarternary.

The mountains west of the steel-works, which seem to terminate abruptly on the south,

and are a part of the Chesnut ridge, are of mica slate, and garnets are not uncommon in this rock.

At the "Stone Church," as it is called, half a mile southwest of Dover plains, the mica slate may be seen well exposed. The Stone Church is a place of some notoriety as a natural curiosity. It is deep chasm of the mica slate rock, worn out much larger by the wearing action of a stream of water. It is very irregular in its dimensions, broader at bottom than at top, with large masses of rocks in the bottom, over which it is necessary for the visitor to clamber to explore its more remote parts. Segments of pot-holes may be seen in the rocks, worn by the action of pebbles and the rapid flow of water. Garnets were seen in the rocks at this place, and a single crystal of staurotide.

Fine specimens of the mica slate containing garnets, may be obtained at the falls of the Wassaic creek, above the furnace in Amenia.

Near the "City," in the northwest part of Amenia, the mica slate passes into talcose slate.

On the road from Amenia northeast to the Chalk-pond ore bed, the limestone, mica slate, and talc slate were all seen in a position nearly horizontal. They may be better examined between the Chalk-pond ore bed, and the village called Perry's corner.

Limestone of a very white color, may be seen a little east of Mr. Ingraham's, three fourths of a mile northeast of Amenia Seminary.

The mica slate is sometimes loaded with iron pyrites. One locality, called the Alum rock, is in the south part of Amenia, not far southeast of the furnace. Another is on the mountain two miles southwest of Amenia, in contorted, talcy, micaceous slate. It is sometimes carbonaceous. It dips ten to forty degrees to the west (Vide Plate 18, fig. 2).

Garnets are stated to be abundant in the mica slate between Beekman and the southwest part of Dover, by Prof. Cassels. White limestone skirts the eastern base of the Chesnut ridge in Dover, and into Pawlings.

The limestone at some of the marble quarries near Dover plains is in nearly vertical strata. Generally, all the strata of rocks in this region dip to the east-southeast at high angles. Professors Cassels and Merrick explored the Dover valley south into Pawlings, almost to Putnam county, and found it skirted nearly the whole distance on the west by white limestone in nearly vertical strata, dipping seventy to eighty-five degrees to the east. The strike was almost north and south.

"The Dutchess county marble varies somewhat in its characters. It is almost always dolomitic, or composed of the carbonates of lime and magnesia in variable proportions. Sometimes it is large grained and quite compact; at others it is fine grained, and so loose in its texture as to be unfit for a building material. A specimen of this marble from Dover, which was of a snow-white color, had a granular texture, and was as friable as loaf sugar, gave upon analysis the following results in 100 parts, viz:

Carbonate of lime, ...	60·50
Carbonate of magnesia, ...	39.50."*

* Prof. BECK's Fourth Geological Report, p. 61, 62.

About one mile and a half southeast of Kline corners, near the line between Kent, Amenia and Dover, heavy beds of close-grained granular quartz were observed. This rock seems to form also a portion of the mountain ranging southwardly, which is called Elbow mountain, and that ranging northwardly, called Peaked mountain in the Reports.* The east side of Elbow mountain trends nearly south; and the west nearly in a southwest direction. The north end presents a sharp summit, but opposite Dover it is three or four miles wide. The quartz rock may be easily examined on the road from Kline corners to Kent, in a field on the north side of the road. It contains some small black crystals in some places, which are probably hornblende or black tourmaline.

This quartz rock is believed to be the same as the Potsdam sandstone, only altered by its proximity to granitic and intrusive rocks; and the same as the quartz rocks described by Professors Hitchcock and Dewey, associated with gneiss and mica slate in the western part of Massachusetts. Between this granular quartz and the Housatonic river in Kent, are three rocky ridges composed of gneiss, gneissoid horblende rock, and granite. The latter was seen only in veins and loose blocks. The other rocks were frequently seen in place, and are like those of the Highlands. On the road from Columbia furnace in Kent to Hitchcock's corners, the only rocks seen abundantly were gneiss and gneissoid hornblende, containing some magnetic oxide of iron. Some of the quartz rock is nearly white, and would probably answer for the manufacture of glass.

Economical applications of the Metamorphic limestones.

The granular limestone of Columbia and Dutchess counties is very extensive, and does not yield to any other mineral deposit in those counties, in prospective value. Marble quarries are extensively wrought in some parts of this range of limestone, and many others will undoubtedly be opened. The limestone extends through the greater part of the length of these counties, and crops out with a variable breadth from a few hundred yards to several miles. It varies much in texture and color. It is granular and compact, white, gray, clouded, striped, and nearly black. In some localities it is strong and difficult to break; in others it is dolomitic and very friable, and crumbles to sand by exposure to the weather. The limestone beds of this range are interstratified with talcose and micaceous slate. They dip to the east and east-southeast from twenty to ninety degrees. It is rarely used except as a wall-stone. Lime has been made from it in Amenia and some other places. It makes a strong and good lime.

The calcareous sand, caused by the disintegration near the surface of many of the beds of dolomitic limestone, may probably be used with advantage on the soil as a substitute for marl. It is found by experience that the lime of these dolomites does not injure vegetation, like that of the European magnesian limestones; and the rock here is pulverulent, and ready to act on vegetation in the same way as marl, and may, it is believed, be used with similar results upon soils that are not calcareous.

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* Vide Second Annual Geological Report of New-York, 1838, p. 172.

The only marble quarries which are extensively wrought in this range of limestone in Dutchess county, are in Dover. The principal quarries are those of Ebenezer Stevens, Elder Foss, John Ketchum, and Nailor Wing. These quarries average about eight thousand feet of white marble slabs per annum. Hess's quarry is three-quarters of a mile north of Stephens's; Ketchum and Wing's one mile east of Stephens's. It is estimated that from twenty thousand to forty thousand feet of marble slabs are sent from the town of Dover in a year, and yield an income of from fifteen thousand to thirty thousand dollars per annum. In the marble mills, a frame of sixteen saws will saw out about two hundred to two hundred and fifty feet per week. The Dover marble is almost a pure white, fine-grained, dolomitic limestone. It works easily, and takes a medium polish. It is nearly all used for grave-stones, and sent to most parts of the United States. Quarries might undoubtedly be opened on the west side of the Dover valley, of as good marble as those on the east. Near Kline corners and Hitchcock's corners are extensive beds of limestone which do not crumble by the action of the weather, and which would make a good marble. In Hillsdale, on Mr. Palmer's land, is a white and clouded marble. It exists abundantly along the base of the mountain.

In Beekman, near Doughty's mills, fine marble, in beds of a few feet in thickness, were observed; as also in several places in Fishkill, near Stormville and Hopewell.

Clouded marbles were observed by Mr. Merrick, on the lands of Mr. Worster Wheeler and E. Merritt in Northeast. The locality on the land of Mr. M. was worked as a marble quarry twenty or thirty years ago, but has been abandoned. It is a beautiful clouded grey marble.

Other quarries have been worked in several places to a small extent, but the demand for the particular kinds was not sufficient to make them profitable.

Marble was sent to the New-York market some years ago from New-Lebanon, which sold for one dollar per square foot. Six quarries were opened in that township, and from one of them slabs fourteen feet in length were obtained.* The limestone beds of New-Lebanon and Hillsdale are interstratified with talcose and talco-argillaceous slates, and seem to pitch under the mountains on the east, which are talcose, mica and chloritic slates. The Stockbridge and Egremont beds, which have many points of resemblance, seem to overlay these same rocks.

The value of the marble quarries in Egremont, Stockbridge, &c. is well known. They are almost as important to our citizens as if they were located within our own boundaries. Their products are entirely sent into our territory and shipped from our ports; and these, together with those of Dutchess county, are supposed to yield about one hundred thousand dollars per annum.

Beds of marble, as good as those of Stockbridge and Egremont, undoubtedly exist in Hillsdale and Copake in Columbia county, west of the mountains; and in Northeast, Amenia, Dover, Pawlings, Beekman and Fishkill, in Dutchess county. The occurrence of beds suitable for marble *west of the mountains*, is important, in consequence of the diminished expense

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* Silliman's Juornal, Vol. 5, p. 10.

of transportation to tide water on the Hudson. The marble trade is already an important branch of industry, and in our territory it must necessarily be one which will rapidly increase in value and importance. The marble beds here and in Westchester county are more convenient to water transportation than in any other parts of the United States, where the marbles are of similar quality. The strata also are thicker, and blocks of almost any desired magnitude can be quarried. The large blocks for the columns of the Girard College, in Philadelphia, are quarried in Egremont, Massachusetts, very near the line of Massachusetts and New-York. The marble business is one that will always employ many men and much capital; and this valuable material is so abundant that it is perfectly inexhaustible in any finite period of time, and it will always be an unfailing source of wealth. I consider the resources of Dutchess county in valuable marbles as inexhaustible.

Altered Taconic rocks through the Highlands.

It was mentioned in the preceding chapter on the Taconic rocks, that in crossing the Highlands, they were more or less altered, and would be described in this chapter on the Metamorphic rocks. It has also been observed that some of the limestones in Beekman and Fishkill, where they approached the Highlands, were white and grey crystalline limestones.

East of Poughquaick in Beekman, the granular quartz rock was seen, having almost the characters of gneiss, and the slate was changed to mica slate. South of Shenandoah in Fishkill, the granular quartz was seen again, and there it was compact and homogeneous like eurite, but retained its strata planes. The associated limestones were grey and white. The dip was in some places almost vertical to the southeast.

The *granular quartz rock* forms a continuous stratum through a portion of Westchester and Putnam counties. It is probably a continuation of the stratum described as forming a part of Peaked and Elbow mountains in Amenia and Dover in Dutchess county, and is probably a continuation of that described by Prof. Hitchcock in the west part of Massachusetts.* The granular quartz rock crops out on the bank of Peekskill bay of the Hudson river, about half a mile northwest of Peekskill landing, near Hall's point. The strata are nearly vertical, leaning a little to the west-northwest. It ranges up the "Peekskill hollow." It is seen in connection with the iron ore at Bradley's ore bed in Peekskill hollow, about ten miles from Peekskill; and again it occurs near Boyd's corners, in Carmel, Putnam county. It is quarried to a small extent near Boyd's corners, for door-steps, hearth-stones, and other purposes. It splits out in regular slabs, from three to nine inches thick, and three to seven or eight feet square, with an uniform plane surface, and is admirably adapted for a flagging stone for streets, cellars, etc.

The locality near Hall's point belongs to ——, of Peekskill. It is at the mouth of Peekskill creek, a little north of Hall's point; and it is believed that a valuable quarry of

* Vide Second Annual Report on the Geological Survey of New-York, p. 172; Hitchcock's Geological Reports of Massachusetts, 1833, pp. 22, 321; Hitchcock's Final Report, 1842, pp. 587, 593; Dewey, American Journal of Science, Vol. 8, &c.

flagging stones, of the granular quartz rock, may be opened at this place. The strata are nearly vertical, and the stones may be split off with great ease, if the quarry be opened in a proper manner. The flagging and curbstone used in New-York, and many other towns, are now brought from the Bolton and Haddam quarries in Connecticut, and from the greywacke quarries in Greene county. The Bolton and Greene county stone are carted from eight to sixteen miles over bad roads, and then shipped to a market. If stone, as beautiful and as durable, can be dug on the shore of the Hudson, where no cartage is required, and where the expense of quarrying is no greater than at the quarries mentioned, and where the business is now very lucrative, it follows that such quarries on the shore of the Hudson would be very valuable.

The *talcose slate*, distinctly characterized, is limited in extent. It occurs in Westchester and Putnam counties, forming a range of hills several miles in length. It forms Blue-rock point, on the post road, between the crossing of Peekskill creek and Annville. The slaty laminæ are parallel in direction to the limestone and granular quartz rock on the east, which dip at an angle of from seventy-five to eighty-five degrees to the east-southeast. This rock forms the principal mass of the hills to the north-northeast of Blue-rock point for several miles. Gallows hill, (a place celebrated during the Revolution, in consequence of the public executions,) is a part of this range of rock. The rock is generally covered by soil, except where it has been denuded by water, or excavations for roads, etc. The soil is of good quality, and produces fine crops. Farther northeast, this rock is rarely seen; but it passes up Peekskill hollow, and up a valley two or three miles west of Boyd's corners in Putnam county. It is very refractory in the fire, and is used for the in-walls of furnaces. The rock is very fissile, and splits in thin laminæ of some magnitude.

Diluvial scratches were observed on the outcropping edges, in many places, where the surface was exposed by uncovering the rock in making and repairing the roads. They are very distinct on the road that passes from Gen. Van Cortlandt's mansion over Gallows hill, on the western declivity. Like hundreds of similar localities observed in Columbia and Dutchess counties, the general direction is from N. 20° to 30° W., to S. 20° to 30° E. Veins of quartz were occasionally seen traversing the talcose slate. In some places the quartz was loaded with pyrites; and where the slate had decayed, and the masses of this mineral were scattered about on the ground, they had the spongy texture similar to the quartz from the veins and nests in the slates of Columbia and Dutchess counties. The cavities are also frequently filled with oxide of iron, like the quartz in the gold region of Virginia and North-Carolina. No gold was, however, seen; and it is hoped that a sufficient number of fruitless researches for *gold*, *silver* and *coal*, have been made in this vicinity, to deter others from future enterprises of such a nature, where the *expense is certain*, and the returns so very, *very uncertain*.

The talcose slate, at its junction with the grey and whitish limestones, is highly loaded with carbon and with pyrites. The one has given origin to the reports and stories of valuable coal beds in this region, and the other to the existence of gold and silver mines.

The slate and limestone glazed with anthracite, and presenting many points of resemblance to anthracite coal, are sufficient to excuse the conclusions of those who have supposed the existence of workable coal beds, and who did not know that such deposits have not been found in such rocks.

The limestones of this range of Taconic rocks are scarcely altered in some places, as at the quarries near Blue-rock point near the mouth of Peekskill creek, and about a quarter of a mile east of Annville; in others it is a perfect metamorphic white limestone, as in the valley west of Gallows hill, two or three miles north of Annville. The following localities of limestone connected with this range of Taconic rocks are easily accessible.

1. *Limestone*, variegated and clouded, occurs one-fourth of a mile south or southeast of Annville, across the marsh from the village near the mouth of Peekskill creek. It may perhaps be used for a marble, but in places it is intermixed with mineral substances which might be an injury to it in polishing and sawing. Its thickness could not be ascertained, as it was mostly covered by the tertiary formation that forms the high steep banks of sixty to one hundred feet deep. Its range is north-northeast and south-southwest, and its dip about seventy degrees to the east-southeast.

2. The same bed of limestone is again seen on the right bank of Peekskill creek, one-fourth of a mile above Blue-rock point. It is on land belonging to Gen. Van Cortlandt, and has been quarried to some extent. It is grey, bluish and variegated, in some places white, and makes good lime. Its range or strike is north-northeast, and its dip nearly vertical. On the west it is bounded by the talcose slate, and at the contact the rock is black, in some places glazed with anthracite, or a substance like it, and it is loaded with cubic crystals of iron pyrites.

3. This limestone reäppears near Gen. Van Cortlandt's mill, one mile north of the locality just mentioned.

4. Limestone makes its appearance as knobs or hills, fifty to one hundred feet high, about two or three miles north of Annville, in the valley west of Gallows hill.

5. Also the same limestone, in the same valley, associated with talcose rocks, two or three miles north of the last locality, near Bonnell's forge. The strata are nearly vertical.

It has been mentioned that this range of Taconic rocks reäppeared on the right bank of the Hudson, between Stony point and Caldwell's landing.

The *Talcose slate*, in Rockland county, is seen on the shore of the Hudson, about one mile and a half or two miles below Caldwell's landing. It passes on the west side of the limestone in which Tompkins's quarries are located, and crops out again in the bay beyond the first quarry, and is seen on the shore west of the second quarry. It continues to bound the limestone on the west, until it finally disappears below the Red-sandstone formation near Capt. DeCamp's, two miles west of Grassy point.* It is a continuation of the bed of talcose

* The conglomerate limestone crosses the Minisheconge creek, near Beebe's furnace, with a breadth of one hundred or two hundred yards, and ranges northeast and southwest. It consists of limestone pebbles, more or less mixed with quartz, hornblende, etc. like the large block deposited in the State Museum at Albany. Talc slate succeeds on the west in

slate described in Westchester and Putnam counties, as ranging from Blue-rock point at the mouth of Peekskill creek, through Gallows hill, and so on into Putnam county. It is adapted for use as a fire-stone for the in-walls of furnaces, but is applied to no use at present.

At the junction of this rock with the limestone at the south end of the Tompkins upper quarry, the rock is loaded with carbon and pyrites. The slate is glazed with films of anthracite, and was supposed to be anthracite coal. Statements were made in the papers of the discovery of a coal mine, and the owner is stated to have been offered five thousand dollars for it, but refused, in consequence of its supposed value. The strike of the junction of the limestone and talc slate here is N. 12° E. The talcose slate and associated *overlying* limestone dip to the east-southeast, at angles of thirty to fifty degrees (Vide Plate 5, fig. 3). The rocks are slightly contorted.

This *limestone* in Rockland county is not very extensive, but, from its location, it is of high economical importance. It skirts the shore of the Hudson for a mile or more, from the landing on the cove at the northwest point of Stony point to a little north of Tompkins's most northern quarry. It extends thence to near Capt. DeCamp's, two miles west of Grassy point, where it disappears beneath the Red-sandstone formation. It occupies an area of some four hundred to six hundred acres, and much of it lies near to the water. It also skirts the west side of the marsh west of Stony point. It is not much altered by metamorphic action, but is like that described in the Taconic rocks. Much of it is sparry, or traversed by veins of white carbonate of lime. Some of it is the grey subcrystalline rock like that in Pineplains, Barnegate, Newburgh, Canaan, New-Lebanon, Stephentown, Whitecreek, &c.; and some is dark, bluish, compact and sparry limestone.

This stone is now quarried extensively on the banks of the Hudson at Tompkins's quarries. Mr. Tompkins purchased twenty acres of this land on the shore of the Hudson in 1837, for one hundred dollars per acre, which *was* thought an extravagant price. It is a ledge of limestone rock seventy-five to one hundred feet above high-water mark, with deep water along side, so that vessels are loaded with great ease. The stratum at the new quarry is from three hundred to five hundred feet thick (measured across the strata), from the shore to its junction with the talcose slate rock. Many thousand tons of this stone are shipped annually to New-Jersey, where it is burnt into lime with dust anthracite at a small expense.* The lime is in part used as a stimulant manure in New-Jersey, and part is barrelled for the New-York market. Each acre of this limestone ought to yield, in course of working down to water level, six hundred thousand barrels of lime, upon which a mean profit of twenty-five cents per bar-

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vertical strata, black and more or less glazed with carbonaceous matter, so as to have given an idea to many persons that coal might be obtained there. Trap dykes intersect the talcose rock. Near the bridge about forty rods higher up the stream, or about one hundred yards across the strata, a granitic rock, having much the aspect of trappean rocks, forms the bank of the creek. The "marble quarry" is a little farther up the stream.

* Dr. Beck has analyzed this limestone, and has found it composed as follows:

Silica and alumina,	7.25
Carbonate of lime,	92.75

(*Fourth Annual Report on the Geology of New-York*, p. 91.)

rel ought to be estimated. Most of this limestone is grey, but some is black and variegated, and might make a pretty marble.

Farther south and west, where this limestone approaches the plutonic rocks, it is metamorphic, as at the two following localities:

1. The "marble quarry," as it is called, is on the banks of the Minisheconge creek, about two and a half miles west of Grassy point. The most extravagant reports were circulated in relation to this quarry soon after its discovery. The rock is composed of serpentine, chlorite, diallage, hornblende, limestone and other substances; and is such a mixture of materials of different degrees of hardness, that it could never be polished with advantage, even if it could be easily quarried.

2. A limestone quarry has been opened about three-fourths of a mile west of Capt. De Camp's, in Haverstraw, on land belonging to John Brooks. Much of the stone is white, granular, crystalline limestone, with thin tortuous black veins of the same material; and if good blocks of this character could be obtained, it would make a beautiful marble. Specimens are deposited in the State Collection. This stone is said to make a fine lime, and one or two kilns of it have been burnt.

Granitic, sienitic, and hornblendic rocks are near to these localities; and the proximity of these plutonic rocks is probably the cause of the altered characters of the limestone, and the intermixture of various mineral substances with it.

Metamorphic limestones of Putnam county.

In tracing these limestones in Dutchess county, we left them in Pawlings. The same granular dolomitic limestone extends south into Patterson, where it is well exposed to view from the north line of Patterson to three or four miles south of the village. It is associated with mica slate and a fissile micaceous gneiss rock. The limestone in the valley of Patterson contains tremolite in some places. About two and a half miles south of Patterson, the limestone is quarried for lime, and forms a superior article. Sixty cords of wood are consumed in burning a kiln of two thousand bushels. The price of this lime is fifty cents per bushel. Much of this stone seems well adapted for a building stone. The rock is granular, strongly coherent, and in color varies from bluish to white. The rock is not fitted for a marble, as the tremolite would make it difficult to saw.

Another quarry has been opened within a mile of the village of Patterson.

About a mile west of Patterson, a ridge of gneiss highly impregnated with pyrites, lies between strata of limestone. The strata through this region dip to the eastward nearly vertically.

Limestone of the same general characters occurs in Southeast, in the valley of the Croton river. It may be seen along the road about a mile above Owensville, and one mile and a half west of Peach pond.*

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* I may be permitted here to mention a circumstance that should have been mentioned on page 41 of this volume. The

Limestone of Westchester and New-York counties.

This rock is abundant, and extensively distributed in the counties of New-York and Westchester. It is all associated with gneiss, mica and talcose slates, and with granite or hornblendic rocks, and is interstratified or embraced as beds in these rocks. In color it varies through white, grey and clouded to black; in texture it is coarsely crystalline, granular, and perfectly compact; in composition, it varies from pure carbonate of lime to magnesian and ferromagnesian carbonate of lime, with variable quantities of earthy impurities; in hardness, from a very strong stone, to one so friable as to be capable of being crushed to sand by pressure in the hand.

This rock is of greater present as well as prospective value in the region of country where it is found, than any other, unless it be the granite, which may, in progress of time, become equally valuable.

Limestone of New-York county.

This rock abounds in the north part of the island, and has been quarried to a considerable extent for marble, building stone, and for lime. (See Plate 30, fig. 7, to illustrate the position, and the surface occupied by this rock.) The length of the exposed limestone is about one and a half miles. It was first seen in place a few rods from the tavern one mile and a quarter south of Kingsbridge, on the road to Manhattanville, and may be seen along the road until after crossing the Spuytenduyvel creek at Kingsbridge. The rock has been called Kingsbridge marble, but it "has been *chiefly* wrought for burning into lime, is mostly of the variety called granular limestone, and is so loose in texture, that after exposure for a time to the weather, it falls to pieces, becoming a kind of calcareous sand." At the junction with the gneiss, "and often for a considerable distance into the marble, it retains the structure of gneiss with the mineral matter of limestone; but where the matter becomes pure limestone, it lies in beds without stratification, or but obscurely stratified.

"At the southern limit of the limestone, where it is from fifty to eighty yards in width, and about one hundred yards west of the road, the strike is N. 30° E., and the dip vertical. It is flanked on both sides by gneiss, and as it continues northerly in the direction of the strike or bearing of the strata, it widens until it becomes from four hundred to six hundred yards in width, and from ten to thirty feet in height, forming a low ridge immediately west of the road, but east of the main ridge of gneiss which flanks the eastern shore of the Hudson, and which terminates at Tubby hook, about half a mile north of the commencement of the lime-

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ice in this pond attaches itself to the loose boulders in shallow water, and floats with them attached, and ploughs up the gravel before them as the ice is driven toward the shore in the spring. In this way they are brought annually nearer and nearer the shore, until they are pushed beyond low-water mark, where they remain. Many of these boulders weigh fifteen or twenty tons. They all seem to have come from one general direction, viz. northwest. Mr. Stephen Ryder pointed out the boulders and furrows, and gave the explanation to Prof. Cassels.

stone. As the gneiss runs out at the mouth of the Spuytenduyvel creek, the whole ridge northward is limestone, the form and extent of which may be learned by inspecting the map of the island, where it is encircled by a line. The strike was examined in a number of places on the ridge of limestone, and varied from N. 25° E. to N. 45° E., and the dip from 50° E. to vertical. From Mr. Dykeman's house, which is near the southern line of the limestone, to the old tide-mill (which is nearly opposite to Tubby hook), at distance half a mile or a little more, is a line of abandoned quarries, which many years ago were extensively wrought for burning into lime; but as the lime was of inferior quality, other varieties at length superseded it. This limestone has been called dolomite, but whether from its granular structure, or from its composition, I am unable to determine."*

Limestone of Westchester county.

The limestone has the same dip and line of bearing as the contiguous gneiss and gneissoid rocks, and like them, is distinctly stratified. They all dip to the east-southeast (as a general rule, but there are local exceptions) at a high angle, varying from forty-five to ninety degrees. The limestone forms several nearly parallel ranges at intervals of two, three or four miles apart, ranging in a north-northeast and south-southwest direction.

1. The most eastwardly deposit of this kind, and of any great magnitude, is seen on Gouverneur Morris's farm, opposite Harlem, where it is quarried for making the piers for the railroad bridge, and for other purposes. It is generally grey, and in some places is much intermixed with mica. Many of the blocks, and even the rocks in place in the quarries, have so much the aspect of gneiss, that close inspection is necessary to distinguish them. The limestone rock again appears in the bed of a small brook between Harlem and Westfarms village. It is thought probable that the Westfarms and Eastchester marble quarries are in this range of limestone, which passes up the valley of the Bronx river by Whiteplains and Rye pond, and so on further to the north-northeast.

2. Another range passes from near Macomb's bridge in a north-northeast direction, is crossed by the aqueduct, and passes about two or two and a half miles west of Whiteplains.

3. Another crosses from New-York island at Kingsbridge, and thence ranges north-northeast, and forms the shore for some distance.

4. Another ranges from Dobbs's ferry, in the same general direction, by the county poor-house and Ackerman's iron mine.

5. Another ranges north-northeast from Sparta, by Singsing, about a mile east of Pine bridge across the Croton river. Some parts of this bed are pure white marble; some are dolomitic, and some have the aspect of gneiss, until closely examined.

6. Another ranges from Verplanck's point north-northeast to near Peekskill, where it changes its direction to the east. A mass of limestone, with a transverse line of bearing, viz. east and west, occurs near Henry J. Cruger's mansion, two and a half miles southeast

* Prof. GALE's Report: Third Annual Geological Report of New-York, 1839, p. 183, 184.

of Verplanck's point. It is supposed to be a displaced, outheaved mass from the preceding range.

7. Another range extends up the valley of Peekskill creek from its mouth, and is a continuation of that in Rockland county, at Tompkins and Marks's quarries, associated with the same rocks.

There are many smaller bodies of limestone, some of which may be parts of the above beds, as there are several lines of transverse stratification, and lateral heaves and faults, that, in some places, render the tracing of the continuity of the beds a matter of much difficulty, and requiring more time than was at my disposal. These beds above described have not all been traced out continuously, and there may be some error in some of them, and there may be more beds than have been indicated, but these bodies are the principal ones.

Local details of the Limestone beds.

A small quarry is opened in the white limestone on the farm of Elijah Martin, two and a half miles west-northwest of Whiteplains. Mr. Cassels estimates its surface width at one-eighth of a mile. It is associated with mica slate. It ranges a little east of north and west of south.

About two and a half miles west of Whiteplains, the bed of limestone is exposed about one-fourth of a mile wide, according to Mr. Cassels; and the range is the same as above, and the dip is at a high angle to the west. It is of a dark grey color, and contains pyrites. It disintegrates where exposed, into a brownish red calcareous sand, which covers the rock in many places. "Black mica slate may be seen a few rods west of the limestone, dipping in the same direction; and a few rods east of the limestone, the same black mica slate may also be seen, having the same strike and dip."* The same limestone was seen three miles southwest of Whiteplains.

A quarry of limestone has been opened in Westchester township, about one-fourth of a mile north of the Harlem bridge. Its color varies from grey to white, and is more or less mixed with mica. Much of this rock would be mistaken for gneiss, without close examination. It dips W.N.W. about 80°, and the line of bearing is N. 25° E. The contact of the limestone with gneiss was observed on the east side of the quarry.

The *Westfarms marble quarry* is about one and a half miles from Westfarms. Little is now done there, although the stone is of as good quality as is usual for this stone. Forty-thousand cubic feet of marble were quarried there in 1837. The proprietor receives six and a quarter cents rent per cubic foot of marble raised. Some large blocks have been quarried, and from appearances more may be procured with little labor. The value of such quarries may be estimated from the rent received by the proprietor, which, for forty thousand feet, the produce of last year, gives two thousand five hundred dollars for one year's rent. The

* Prof. Cassels's Geological Notes of the New-York Survey, Vol. 7, p. 7.

excavation is small, and apparently the opening of the quarry is but commenced. The refuse stones of the quarry are burnt into lime for manure, with dust anthracite coal, which can be purchased at the coal-yards in New-York for seventy-five cents per ton.

The *Eastchester marble quarry* is near the road from Whiteplains to New-York, and near the left bank of the Bronx river. The marble is white and crystalline, and is distinctly stratified, though some of the strata are several feet thick. The dip is about 80° westwardly; the strike N. 32° E. It is worked by Kane and Morgan, and there are few quarries in the country more extensively worked. They sell about sixty thousand to seventy thousand cubic feet of marble per annum, a large portion of which is in large blocks from two to twenty tons weight, for columns and cornices of large buildings. The heavy blocks wrought into the forms required sell for from four to five dollars per cubic foot; the smaller ones for one dollar per foot. This quarry affords great facilities for obtaining large masses. At the time of my visit, they were quarrying a block one hundred and fifty feet long, eight feet thick and seven feet broad. This was then to be blocked up into such sized and shaped masses as might be desired, and which can be done with little waste. It was estimated that this mass, when blocked up and worked, would be worth twenty thousand dollars. This quarry was opened in 1822, and has been more or less extensively worked to the present time. The marble is transported five to six miles, and then shipped to New-York and other places. The New-York Custom House, the Brooklyn Exchange, and other buildings in those cities, are built of stone from this quarry. The heavy blocks are raised by a crane and screw, and swung under vehicles with four large wheels, by which they are transported by large teams of horses or mules to water transport, where they are put on board of vessels by means of a crane. They are landed in Brooklyn, New-York, &c. in the same way, and again swung under large heavy carriages, and hauled by teams to their destination.

The *limestone of Cross pond*, in Westchester county, was also examined by Prof. Cassels. It alternates several times with gneiss in the breadth of one-fourth of a mile. He states the strike of the rock at N. 30° E., and the dip at eighty degrees westward. It may be seen at the south end of the pond near Mr. Knapp's house, in the hill east of the house.

Limestone interstratified with gneiss was also seen by Mr. C. on the banks of Long pond, and between Long and South ponds. It is supposed to range through both ponds. The *strike of these beds is about N. 70° E.*, and the dip about sixty degrees to the south-south-east. Good lime was made from this limestone about twenty-five years ago, but the expense of the fuel necessary for burning it stopped the business. The gneiss (or micaceous gneiss?) bounds the limestone on both sides.

Limestone occurs at Bedford village, opposite the boarding school, where it was examined by Prof. Cassels. But little of the rock was exposed to view, and he did not ascertain the strike and dip.

About half a mile east of Bedford village, a bed of limestone was examined by Prof. Cassels. It forms a low ridge on the land of Mr. Frost, and was opened some years ago for the purpose of making lime. Good lime is said to have been obtained. The rock is granular,

white and grey, and not easily disintegrated, and would, it is supposed by Mr. Cassels, make a good marble. The rock is stratified and somewhat contorted.

Granular limestone occurs four miles northeast of Singsing, at Sarties' hotel, where it was observed by Prof. Cassels. He did not note its strike or dip. Not far from the same place, I observed the white and grey limestone, *ranging N.* 60° *E.*, and dipping north-northwest about forty-five degrees. It is exposed in several places in the vicinity of the Croton aqueduct, within one mile and a half of the dam. Limestone was also seen about two and a half miles from Singsing, near Mud millpond; and south two or three miles from this place, it is presumed there is limestone (although it was not seen), as there is said to be a cave. The locality of the cave is said to be near Pleasantville, about on the line between Mount-Pleasant and Newcastle townships.

At Singsing, the limestone is extensively quarried on the State farm, by the convicts in the State Prison. Almost all the limestone of these quarries crumbles by long exposure to the action of the weather; but when kept dry, it is said to be a durable stone. Near the surface of the earth this rock is a perfect dolomite, covered by calcareous sand from the crumbling rock. Much of the rock in the spoil-banks that had been removed from the top of the quarries was so friable that it could be crushed to sand by pressure in the hands At a greater depth in the quarries, the rock is sound, crystalline, hard and tough. The bluish marbles seem the most durable, though all of them crumble by long exposure. This stone is extensively used as a building material, but in many instances it has already begun to crumble away. Examples may be seen in the stones at the bottom of the iron railing around the Capitol square, and the Albany Academy square, in Albany. Many blocks of this rock were brought to Albany for the construction of the New-State Hall, that were already crumbling; but whether they were put in the structure, or rejected by the builders as they ought to have been, I do not know.*

Lime is made from this limestone at the quarries, not only for consumption at the prison, but for sale. Large quanties of the stone are sold for the New-Jersey limekilns, where it is burnt with dust anthracite coal for manure.

This stone is also used as a flux in the Coldspring furnace. For the above purposes of lime and flux, the stone is sold at the wharf at thirty-seven and a half cents per ton.

Limestone lines the shore from Singsing landing to Sparta landing, where its contact with granite is seen. The limestone here has the aspect of having been upturned, and its layers pitch down towards the granite (Vide Pl. 5, fig. 2). This locality is on the north side of the point at Sparta, on the north side of the brick-yard. The range of the above limestone is N. 32° E., and the ridge of granite trends in the same direction. About thirty or forty rods to the eastward, the dip of the limestone is sixty to seventy degrees to the eastward; but in a few rods to the north it is vertical, and resumes its strike of N. 20° E.

About one hundred and fifty yards southeast of the adit that was opened to strike a vein of

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* I have often observed that architects and builders in our country rarely exercise that care in the selection of materials for *durability*, that they ought, both for their own reputation, and the profit of their employers.

copper ore, on the shore near Sparta, is apparently a continuation of the bed of feldspathic, quartzose, laminated rock, containing copper, like that in the shaft of the mine; but if it be the same, there is probably a fault that has heaved the rock laterally about fifty or sixty yards. Augite, asbestus, and other minerals are much mixed with the limestone near the granite by the brick-yard, and near the "Copper mine,"* and also in "Murray mountain," one hundred to two hundred yards southeast of the brick-yard. The augite is both white and green, the felspar is in several places petuntze, and is passing rapidly into kaolin. Carbonate of copper is seen oozing from the crevices in the rock.

The strata of limestone north of the prison are nearly vertical, and is distinctly stratified as gneiss. Crystallized pyrites, magnetic pyrites, and sometimes copper pyrites are found in particular layers of the rock. Some singular aggregates of limestone with augite, quartz, felspar, mica, pyrites, etc., may be seen by tracing the limestone ledges along the shore, where they are beautifully exposed to observation between Sparta and Singsing landings, both above and below the State Prison.

The old *silver mine*, as it is called, is on the shore of the Hudson a little above the prison, and on the State farm. There are no indications on the surface that would indicate any valuable ore in any valuable quantity. The rock is an impure limestone, containing augite and some magnetic sulphuret of iron. Some of this sulphuret of iron, when carefully tested by cupellation, gave no trace of silver. Similar layers of rock containing the augite and magnetic pyrites, extend through the ledges parallel to the strata both in strike and dip, for forty or fifty rods along the shore. It was carefully examined for native silver (which is said to have been found at the mine), and for the various ores of silver, but without observing a trace of any silver ore, or of any other ore that would be likely to contain it, except the pyrites. This mine was worked before the Revolution, by a British officer who resided in New-York. The shaft is said to have been one hundred and fifty feet deep, and galleries to have been excavated in different directions, principally in a north and south direction, or along the line of strike. Gen. Pierre Van Cortlandt remembers when the mine was wrought, and when a boy, was in it. The mouth of the shaft is on the shore of the Hudson, a little above high-water mark. The mine was drained some years ago by a company, but the work was not resumed. It is to be presumed that they found no indications to justify the expense of prosecuting the work.

A quarry is opened in a *bed of limestone* on the hill northeast of Sparta. It is coarsely crystalline, and very beautiful. Small pieces of serpentine, and traces of iron and copper pyrites, were observed very sparsely disseminated through the mass. It seems a more durable limestone, and less prone to disintegration than that at most of the quarries. This range

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* The copper ore at Sparta was discovered by Mr. Cartwright, a company was organized, and a charter obtained for a capital of one hundred thousand dollars. The company sold out their interest to individuals in New-York. A shaft was sunk forty or fifty feet, and an adit level excavated from high water mark on the shore, in a direction N. 20° E. along the line of bearing. In some few places the lode of copper pyrites is said to have been six inches thick; but only a few tons of ore were obtained, not enough, as a shrewd old miner who had worked there justly remarked, to pay for the candles.

of limestone is about a quarter of a mile broad, and extends from Sparta through Mount-Pleasant.

A bed of *dolomitic limestone* occurs near the county poor-house of Westchester county. It is called sandstone by the people, because it crumbles to sand by exposure to the weather. The same bed was seen at intervals to Dobbs's ferry. It crosses the valley of a small stream near the church on the hill, and it forms the shore below Dobbs's ferry. A quarry is opened in this bed one-eighth of a mile from the shore of the Hudson, a mile below Dobbs's ferry, and a railroad and wharf have been constructed to facilitate the transport and embarkation of the marble. Lime has been burnt from this stone on the shore, and some of the rock has been transported to New-York and burnt. This limestone is intersected, and was cut through, in excavating the Croton aqueduct, between Tarrytown and Dobbs's ferry.

Limestone crops out on the hill east-southeast of Peekskill. It is much contorted and variously clouded, and some of it may, perhaps, be used for an ornamental marble. It also crops out near the lower dock at Peekskill, and is bounded on the east by hornblende rock. It ranges nearly east and west, and is on one of the transverse axes of disturbance.

A bed of limestone occurs five miles from Peekskill, on the road to Crum ponds. It is a dolomitic limestone that is used for marble, for making lime, and for sand. For the latter purpose, the crumbling rock is crushed by a stone roller, and the mortar is said to set well in which it is used. Similar sand in some other parts of the country will *not* form a strong mortar.

Limestone of good quality occurs on Abraham Miller's farm, on Mill creek, which is the outlet of Crum ponds. The locality is stated by Prof. Cassels, who examined it, to be five and a half miles southwest of Somerstown plain, and three miles south-southeast of Crum-ponds village. The strike is N. 30° E., and dip seventy-five degrees eastwardly. Mr. Miller has made lime from the stone of his quarry for four years. He makes five kilns of lime per annum, each of six hundred bushels, the average price of which is fifty cents per bushel at the kiln. Twenty cords of wood, at three dollars per cord, are used to a kiln, and six days are required for the burning. The limestone lies in high knobs, and can be easily opened on the northeast side, and Prof. Cassels thinks good marble may here be obtained. This locality is about two miles west of Whitlock village, through which it is supposed the New-York and Albany railroad will pass.

Limestone was seen by Prof. Cassels on Plumb creek, about a mile west of Somerstown plains, on the Peekskill road. It occurs along the road for about half a mile.

Limestone occurs about two miles north of Whitlockville. It is also said to occur on Mr. Todd's farm, about a mile east of the locality above, where it has been used for making lime. Prof. Cassels saw it again about three-fourths of a mile south of the crossing of Titicus river. It is here abundant, and fine quarries might be opened. It crops out on the road side occasionally all the way to North-Salem, where it is abundant and highly crystalline. A stratum of limestone was seen by Prof. Cassels about a mile north of Owenville, and again about a mile and a half west of Peach pond.

A bed of limestone is quarried for lime about thirty or forty rods west of Hardy's hotel, at

Verplanck. This stratum is bounded on the west by hornblende slate, and on the east by hornblende rock. This stratum crosses the road about three-fourths of a mile north-northeast of Hardy's hotel.

Limestone forms the shore at Verplanck landing, and skirts it for one mile to one and one-fourth miles up Peekskill bay.

Near Verplanck landing, the limestone is much injected with veins of hornblende, so as to unfit it for making lime. This place is well worth the attention of geologists, as showing the intrusion of one rock into another. At a small distance north of the landing, the limestone is free of hornblende, and is nearly a pure limestone, making very good lime, and which is said to be equal to the Thomaston and Rhode-Island lime. As to the quantity of stone here accessible and adapted for lime, we may estimate the mean height above high water mark at twenty-one feet over an area of fifty to eighty acres, lining the shore of the bay nearly a mile in length. Each cubic yard of rock will make at least four barrels of lime, including the necessary waste. This would give about 135,000 barrels to the acre; or, for sixty acres, 8,100,000 barrels of lime. Two kilns were burning as perpetual kilns at the time of my visit. They produce twenty-five barrels of lime per diem, with a consumption of one ton of anthracite coal.* The expense of quarrying the stone is about thirty-six cents per cubic yard, or nine cents per barrel. The expense of coal is about twenty-five cents per barrel. The lime was stated to be selling at New-York, at the time of my visit, for one dollar and fifty cents per barrel; giving a profit, after deducting every expense, including teams, attendance, freight, casks and cooperage, of fifty-three cents per barrel. If we allow a nett profit of only twenty-five cents per barrel, an acre of this limestone of twenty-one feet thick, is *capable* of yielding a clear profit of $33,880.

Some parts of the limestone along the shore above Verplanck's point seem adapted for marble, and if worked into, beyond the effects of atmospheric changes, might afford as good monumental marbles as the quarries of Berkshire county, Massachusetts. The rock, where it appears suitable, might be uncovered free of expense, by burning the stone for lime. Should the rock at this place prove suitable for a marble, it might be quarried and sent to market at less expense, as here it is on navigable water, and no land transportation required. The expense of sawing here would undoubtedly be greater, but the increase would not be equal to the expense of land transport twenty-five to thirty-five miles over the mountain to the Hudson river.

Hornblendic rocks skirt the shore from Peekskill to within about two miles of Verplanck's point. They are similar, and a continuation of the same bed that extends from Verplanck's point northward, bounding the limestone on the east. This rock is in some places coarsely stratified, and then the strata dip to the westward twenty to thirty degrees. A thin stratum or bed of granite of a nearly white color, was seen on the shore three-quarters of a mile below Peekskill. Much of the hornblendic rock approaches in appearance to the Quincy sienite, and

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* This stone must be difficult to burn, or else the coal is not used to advantage, either from a defective form of the kiln, or bad management of the workmen. At Barnegate, ten times as much lime is obtained with the same fuel.

would be equally durable and easily wrought. It is composed of felspar and hornblende, and sienite or greenstone would be an appropriate name. It is generally about as coarse grained as the Quincy sienite; but some beds of the rock contain a considerable quantity of magnetic oxide of iron in grains, so that it exercises a strong influence over the magnetic needle. This may be seen very distinctly near the little islands of this rock east or southeast of Verplanck's point. These hornblendic rocks that contain magnetic oxide of iron, disintegrate more readily than the others, and form a red soil. Some of the hornblendic rocks near the limestone and east of it, are hornblende slate and hornblendic gneiss.

About two miles below Peekskill, the hornblendic rock is succeeded by limestone, which is generally, though not always stratified. In some places the limestone is contorted in almost every variety of form that can be conceived, and is more or less intermixed with augite, tremolite, mica, etc.

Near the place where the limestone is first seen on the shore, proceeding from Peekskill to Verplanck, it is in very thin layers. In some places these layers are nearly plane; in some, arched; in others, crumpled in every way with zigzag and winding layers, as is represented on Plate 9, figs. 16, 19; Plate 10, fig. 13; and Plate 30, figs. 1, 2, 3. The limestone, where it is so much contorted, seems too impure to be burnt for lime; but farther along the shore towards Verplanck, the rock becomes more massive. The rock is white, grey and variegated in color.

The rocks below Verplanck along the shore are hornblendic, and like those described as lying east of the limestone. They consist of sienite, hornblendic gneiss, hornblende slate, with veins and interstratified masses of reddish granite, and extend to within about one-quarter of a mile of Mr. H. J. Cruger's mansion, where mica slate succeeds, and continues to near Mr. C.'s. The mica slate is succeeded on the east by a bed of white limestone of much economical importance. It is about three miles southeast of Verplanck, and forms the shore half a mile east or southeast of Mr. C.'s mansion, and it extends eastward from the shore into the interior. Some of it is adapted for a marble, which may be obtained in blocks of considerable size on the shore. It is already quarried for lime, the stone for which is shipped to New-Jersey, where it is burnt for the New-York market and for manure, with dust anthracite coal, at a small expense, and with a handsome profit. The stone is sold to the vessels at thirty-seven and a half to fifty cents per ton on the shore where it is quarried.

This bed of limestone forms the shore of Haverstraw bay for more than a mile, extending from the mouth of the brook near H. J. Cruger's sawmill, to the mouth of another small brook on Nicholas Cruger's farm.

Some estimate of the value of these limestone beds may be formed from the fact, that the blocks can be swung on board sloops by means of cranes, without any land transport, and that each acre may be made to yield from one hundred thousand to five hundred thousand barrels of lime; or for shipment, each acre will, on an average, yield about one hundred thousand tons of stone suitable for burning.

This limestone bed is succeeded on the east by hornblendic gneiss, with heavy beds of reddish granite. Plate 14, figure 7, shows a section of the rocks as far as observed between Verplanck's and Cruger's points.

Limestone was observed in two places between Verplanck and Henry J. Cruger's, by the upper road; one was near the church.

Plate 14, fig. 5, exhibits the rocks and their position as observed by Prof. Cassels, between Tarrytown and Whiteplains; but there is one bed of limestone that undoubtedly crosses the line of that section in the valley of Sawmill river, that was not seen. The bed has been examined both north and south of the line of section, and where the section was made, was probably covered by alluvial or quaternary depositions.

As the rocks associated with the limestone have been traced along the shore from Peekskill to Sparta, except where the quaternary and alluvial depositions occupied it at Teller's point, and a mile or two above, I will continue to trace them with the associated limestone beds that reach the Hudson successively.

Hornblendic gneiss with veins, interlaminated beds, and irregular masses of granite, form the shore from Sparta to near Tarrytown. These rocks are finely exposed to view, and are worthy of a more rigid examination than I was enabled to make of them. Some of the gneiss rocks contain no hornblende, and some are very micaceous. The gneiss that contains no hornblende, is generally red like that at Mrs. Beekman's quarry, about two miles north of Tarrytown, and the granite beds and veins are of the same color.

From Tarrytown to below Dobbs's ferry, the shore is mostly skirted by the quaternary formation; but the rocks frequently emerge along the shore, and are mostly varieties of gneiss. About one and a half miles below Dobbs's ferry, the white granular limestone emerged on the shore, and extended along it for a mile or more. The reddish color of the soil and of the rocks for some distance before the limestone was seen, had been observed, and was known to indicate the proximity of that rock. Some of this limestone will make good lime, and perhaps good marble; but much of it is interstratified with layers of a siliceous limestone loaded with magnetic sulphuret of iron, like similar layers on the shore between Singsing dock and the State Prison.

A limestone quarry is worked near the shore in this bed of limestone, about one and a half miles below Dobbs's ferry, and a railway with a double track is laid to transport the stone from the quarry to the wharf. The rock is a beautiful white crystalline limestone, and if the quarry should be worked to a greater depth, would probably afford large and sound blocks of good marble. Gneissoid rocks which are frequently hornblendic, succeed the limestone on the east, and emerge successively on the shore between this limestone bed and Yonkers. The rocks are not seen continuously on the shore, but they emerge occasionally through the quaternary.

The rocks continue about the same to the mouth of Spuytenduyvel creek, at the north end of New-York island, where the limestone of Kingsbridge, which has already been described, succeeds, and occupies the shore of the creek for a half mile or more; while gneiss, with granite in beds and veins, forms the rocky ridge on the west, along the western shore of the island from Tubby hook southwards.

There are a few beds more of the Metamorphic limestones somewhat different in character, that remain to be described in this class, viz. that of the Anthophyllite locality in the city of

New-York; that of the "Marble quarries" of New-Rochelle, and some other similar beds. Prof. Gale, who examined in detail the geology of New-York island, describes the anthophyllite locality as follows:

"*Hydrous anthophyllite.* This rock has been familiarly known for many years in this vicinity, under the name of *radiated asbestus rock;* but was known only as a boulder found in considerable abundance in various parts of the city, and as far north as Fifteenth or Twentieth-street. Its geological place was not, however, known at that time; and as its true mineralogical character was somewhat doubtful, Dr. Torrey sent specimens of it to Prof. Thomson of Glasgow, who analyzed it and pronounced it anthophyllite; but as it contained a much larger proportion of water than had usually been found in this mineral, Dr. Torrey proposed to prefix the term *hydrous,* which has been generally adopted. This rock has been found in place on the west side of the island, between Tenth avenue and the Hudson, and between Fiftyseventh-street on the south, and Sixtythird-street on the north. Here the strata are nearly vertical; the strike is north-northeast; the width of the bed at right angles to the strike varies from three to thirty rods. It commences at Fiftyseventh-street, within thirty or forty feet of the avenue, and runs obliquely to the streets crossing the Eleventh avenue near Sixtieth-street, and runs out at the river on Sixtythird-street. It is remarkable that the granite lying on the west, and the gneiss on the east of the rock in question, come in complete contact with it without intermixing. So remarkable is the line of separation on the side next to the gneiss, where there is the best opportunity to examine the two, that within the space of three inches each rock possesses all of its own peculiarities, with none of those of its neighbor. The mineral character of this rock varies much in different parts of the bed. In the southeast portion, where it approaches nearest to Tenth avenue, it exhibits little or no stratification, is very dark colored, and has a tabular structure. In the same vicinity are found masses of serpentine and limestone intermixed, exhibiting a porphyritic appearance, the serpentine appearing green, and the limestone white. Again, near the middle of its course, or near where it crosses the Eleventh avenue, it becomes lighter in color, more fibrous and scopiform in structure; but the fibres are large, and in some instances approach the character of actynolite. Still lower down, following the strike towards the river, the same mineral character continues, except that the fibres are still finer, and the whole texture becomes softer and more like steatite; so that many years ago, before the rock was known to geologists, it was attempted to work this bed for a soapstone quarry, to be applied for similar useful purposes; but the material being too hard, the project failed."*

Another locality of serpentine rock, with radiating fibres of anthophyllite? occurs in a southeasterly direction from Whiteplains three or four miles. I did not see it, but was informed of it after I had left that part of the country. I had inferred the existence of such a locality, from the boulders of this rock which I saw scattered over the fields. Another locality is in Philipstown, Putnam county, about ten or eleven miles north-northeast of Peekskill,

* Prof. GALE's Report on the Geology of New-York Island, in the Third Annual Report of New-York, 1839, p. 193.

and about half or three-quarters of a mile east of Horton's pond. The rock is of a blackish green, fine grained, and sometimes coarsely crystalline. It is yellow on the weathered surfaces, and is associated with steatite. Ten to eleven acres seem to be underlaid by this rock, which might be quarried for an ornamental marble. It is about eight miles from water transport.

Another mass of the serpentine rock was seen about a mile south of the one last described. The serpentine forms knobs and hillocks at small intervals for half a mile in length.

Another locality, one that has already attracted much notice, is Brown's quarry, near Pine pond in Putnam county, four or five miles from Putnam court-house, and one and a quarter miles north-northwest of the county poor-house. It is dark colored, dark green to black, and from compact to a coarse crystalline, like coarse grained hornblende rock. It is granularly foliated like common white marble, polishes well, and is perfectly black when polished. It may be obtained in large blocks for sawing into slabs. Large blocks lie on the surface in Brown's lot, and the rock is seen in place all around the hill. In the mine lot adjacent, good blocks may probably be obtained by quarrying. Twenty-five to thirty acres of ground are underlaid by this rock on the hill-side, west of the brook, which is the outlet of Pine pond. It is easily accessible, and about one hundred feet above the water level of the adjacent valley. Blocks of many tons weight can be easily procured; in fact many of this size are now lying on the surface, and require no blasting or splitting before they are put in the sawmill. Magnetic oxide of iron, or chromate of iron, is disseminated through the serpentine in some parts of the serpentine bed; and this variety of the rock will not be suitable to work, as it can neither be sawed nor polished easily. The quarry seems to be sufficient to supply the market, not only of our own country, but the world, with this kind of ornamental marble for a long time. It is really a beautiful material when polished, and it is hoped that it will be extensively used. I have seen no other locality where such a material can be obtained in so large blocks, sound and free from seams and cracks. A marble of this kind was used in ancient times in some of the old Spanish palaces, but it is exceedingly rare in Europe.

Another locality of it may be seen on the peninsula east of New-Rochelle. It has been quarried to a small extent for marble; but it is understood that good blocks, free from cracks, could not be procured. The serpentine at this locality shows almost every shade of color and texture, from black to light yellowish grey, and from compact and crystalline to earthy. It is bounded by hornblendic rocks on the west, and by limestone more or less mixed with serpentine and with siliceous matter on the east. Among the minerals noticed here, may be mentioned *verd antique; precious serpentine* of a red, green and yellow color; *common serpentine*, green, yellow, grey, black, compact, granular and earthy; *jasper*, *chalcedony*, *agate*, *drusy quartz*, *marmolite*, *hydrate of magnesia; carbonate of magnesia*, compact and crystalline; *tremolite*, *magnetic oxide of iron*, and *chromate of iron?*

The locality where the quarrying operations were carried on, was at high-water mark, and they dug perhaps too near the level of low water. Good blocks of this rock could scarcely be expected free from cracks, where they had been exposed to the beating surf and the winter's

frosts for ages. A large portion of the hill south of the beach, and of the locality at the southeast end of the beach, is composed of serpentine rock, and it is not impossible that quarries of some value may be opened there. This is an interesting locality. The serpentine farther south on the neck of land is like that of Hoboken and Staten island.

"It was at one time supposed that the serpentine found here, from its beautifully variegated green color and its resemblance to the Italian *verd antico*, might be employed as an ornamental marble. But a careful examination of the material proved that it was traversed by seams and cracks, which everywhere divide it into small masses. It is also penetrated by other minerals, which, however they may add to its interest for cabinet specimens, render it unfit for the uses to which marble is applied. In a similar bed in the town of Rye, other and more rare magnesian minerals are found. Chromate of iron, the ore from which the chrome yellow of commerce is obtained, is here often disseminated through the serpentine, as it is also, although less abundantly, at New-Rochelle. It is doubtful, however, whether at either locality it exists in sufficient quantity to answer any useful purpose."*

Recapitulation, and Theoretical Considerations.

In describing the Metamorphic limestones of Dutchess, Putnam, Westchester and New-York counties, we have traced them in different localities through various modifications of texture, from the grey and semi-crystalline limestones associated with talcose slate and the sandstone of the Taconic system, to the perfect dolomites and white and grey crystalline marbles associated with mica slate and granular quartz rock, north of the Highlands; and to still more crystalline limestones associated with mica slate, micaceous gneiss, hornblende slate, hornblendic gneiss, hornblende rock, sienite and granite, south of the Highlands; and in these latter limestones, we frequently find some mineral substances, such as serpentine, brown tourmaline, copper and iron pyrites, magnetic sulphuret of iron, mica and magnesian minerals, particularly where they are near to undoubted plutonic rocks. These have been traced within the boundaries of New-York, between Mount Washington in the southwest corner of Massachusetts, and the city of New-York. The same may be observed in tracing the rocks of the Taconic system eastwards, from Washington county into Vermont; from Rensselaer and Columbia counties, to the Hoosick mountains in the eastern part of Berkshire county in Massachusetts; and from Dutchess, Putnam and Westchester counties, into Litchfield and Fairfield counties in Connecticut.

The same rocks are found in those three States on the eastern side of New-York, and I have examined them with some care. Prof. Hitchcock has well and correctly described those of Massachusetts, and he considers them metamorphic rocks,† but was not able to refer them definitely to any particular geological age,‡ and it could not be done by studying the rocks of Massachusetts alone. To Prof. Emmons is due the credit of first rendering it highly probable that the limestone of Burlington in Vermont is the same as that which is marble in

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* Prof. Beck, Fifth Annual Geological Report of New-York, 1841, p. 12.

† Final Geological Report of Massachusetts, 1841, p. 587. ‡ Ibid. pp. 573, 581.

Berkshire county in Massachusetts. In tracing the superposition of the rocks in Essex county, from the Potsdam sandstone, which rests on the Primary rocks, he run his section across Lake Champlain into Vermont. Describing his section,* he says, "Now the most important fact in this section, is the position of the last member of the group, the grey limestone. It is a stratum which, in Berkshire county and other parts of the country, has generally been placed among the primary rocks; it is identical with the limestone at the base of Saddle mountain, and which covers more or less of the western flank of the Green mountains. As yet I have not been able to find any very distinctive difference between it and the white and grey marbles along the whole range just mentioned. No one has ever doubted the primary character of these marbles; yet, if the preceding views are correct, will they not have to be removed into the *transition class?* That there is a well marked difference between the marbles and what I have in another place described as the *true primary limestone*, I cannot doubt.† The whole matter evidently requires a reëxamination; and if the above remarks lead only to this result, I shall be repaid the labor of all the attention I have bestowed upon them, though other opinions than those expressed above are finally adopted."*

Prof. Hitchcock has traced the connection of the granular quartz rock, in patches highly inclined, with gneiss, mica slate, talc slate, argillite and limestone,‡ the dolomitization of the limestone, and the almost constant intervention of the mica slate between the dolomite and talc slate.§ This intervention he attributes, it is believed justly, to the limestone absorbing the magnesia from the talc,‖ while subject to metamorphic agency.

Prof. Hitchcock has also shown that the white crystalline limestone of Bernardston, Massachusetts, contains fossil remains. Quartz rock overlies, and argillaceous slate underlies the limestone, though the contact was not seen.¶ The slate and limestone in this range of rock extending into Vermont, are very similar to the corresponding rocks in New-York and Massachusetts.

After reviewing all the facts observed both by others and myself, I have been led to the conclusion, *that the limestones that are frequently crystalline, white and variegated marbles* in the western parts of Vermont, Massachusetts and Connecticut, and in the eastern part of New-York, from Mount Washington to the city of New-York (that have been described in this chapter), ARE METAMORPHIC ROCKS; *that they were originally the Mohawk limestone and Calciferous sandstone,* and *that the associated rocks were originally the Potsdam sandstone and the slate rocks of the Hudson valley;* that *they were,* in fact, *the rocks of the Champlain division, but much more altered and modified* by metamorphic agency *than the Taconic rocks.*

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* Vide Second Annual Geological Report of New-York, 1838, p. 232.

† The "true primary limestone" here alluded to, is the same that forms the second class of Metamorphic limestones in this volume, and which is next to be described as the metamorphic limestones of the Highlands and west of the Hudson, and of Washington county.

‡ Final Geological Report of Massachusetts, 1841, p. 589. § Ibid. p. 573. ‖ Ibid. p. 582, 584. ¶ Ibid. p. 560, 561.

II. METAMORPHIC ROCKS OF THE HIGHLANDS, AND OF SARATOGA AND WASHINGTON COUNTIES.

The limestones are the rocks in which the metamorphic action is most distinctly traceable, and to these the discussion will be *mostly* confined.

They are generally coarse-grained crystalline limestones, of a white color, and sometimes of a flesh-red color, embracing a great variety of crystallized minerals. Plumbago in hexagonal scales, brucite or chondrodite, and spinelle, are almost constantly associated, and very frequently augite of several varieties, sphene, mica, amphibole several varieties, serpentine, diallage, phosphate of lime, and a great variety of minerals which will be mentioned in the proper place.

"In regard to the rarer minerals found in the white limestone group in the northern and southern parts of the State, there is a similarity; while there are, it is true, some points of difference. Serpentine of various shades, and often assuming a semi-crystalline form, is equally common in both, together with occasional crystals of mica, blades of plumbago, etc. There are also to be found in them hornblende in all its varieties, pyroxene, scapolite, phosphate of lime, zircon, sphene, tourmaline, garnet, brucite and spinelle. The two last named minerals, however, have heretofore been found in much less abundance in the north than in the south. Orange county is particularly rich in localities of these interesting and elsewhere rare minerals."*

This limestone is the same in character as that described by Prof. Emmons in the Second Annual Geological Report of New-York, 1838, pp. 196, 205, as primary limestone, and like that, is associated with similar rocks, is not generally stratified, is frequently intertruded among plutonic rocks, and has plutonic rocks intertruded as veins and beds through and between parts of its mass.

In Orange county (New-York), and Sussex county (New-Jersey), all the changes from the grey and blue limestones (Mohawk limestone and Calciferous sandstone of the New-York Reports, and Formation No. 2 of the Pennsylvania Survey), can be distinctly traced into the perfectly crystallized limestone, containing the various crystallized minerals; so that it is believed that most of those who will examine the rocks thoroughly, will admit that they are metamorphic.

I spent about two weeks examining the limestone region in Warwick, in 1828 and 1838. Unfortunately, the notes made of particular localities have been lost; so that I cannot go into that *detail* of personal observations, with references to particular localities, with drawings and diagrams for illustration, that I could wish. I can only state general results, and details drawn from the published observations of others. Prof. H. D. Rodgers and Prof. C. U. Shepard have described these rocks as they occur near Pochunk mountain, Mount Adam,

* Prof. Beck's comparison in the Fourth Annual Geological Report of New-York, 1840, p. 50.

Mount Eve, and southwards into New-Jersey. In discussing this particular mass of Metamorphic limestone, many observations made by those gentlemen, Dr. Horton and myself, will be adduced.

(a). *White Metamorphic Limestone of Warwick.*

This limestone ranges south-southwest from Mount Adam and Mount Eve in Warwick, Orange county, to Andover and Lockwood in New-Jersey. It extends along the east side of Mount Eve, nearly to the line of the township of Goshen. "Its southeastern limit is very straight and well defined, until it enters New-Jersey. Its western is irregular, passing along the side of Pochunk mountain; thence near the margin of the Drowned lands, across the Pochunk creek to Mount Adam. It also passes some distance between Mounts Adam and Eve. At its widest part its extent is more than three miles."* This is at the line between New-York and New-Jersey. It is frequently only a few rods in breadth, or else is a succession of narrow ridges of limestone, separated by masses of other rocks, of granite, sienite, or anomalous aggregates, some of which seem to have been granular quartz rock. Granite veins and masses of quartz, hornblende rock, augite, and mixtures of them, are seen almost every where, when closely examined. They traverse the rocks in various directions, but most frequently parallel to the strike, or else in a west-northwest and east-southeast direction. The strike is about N. 30° to 40° E.

The white limestone is rarely stratified, or shows any distinct traces of stratification; but in some places it exhibits a regular gradation into the grey and blue limestone, which is fossiliferous in some places and oolitic in others, and stratified in nearly horizontal strata. Dr. Horton observed, that in a few localities, the blue limestone was inclined at a high angle, and particularly south of the village of Edenville; and that the white limestone in some places showed an apparent stratification with a dip to the southeast, but they were very limited in extent. The white limestone is confined to the lower parts of the valley, its ridges rarely rising one hundred feet above the Drowned lands,† except on Mounts Adam and Eve. Its color is generally white, having the character of calcareous spar. In some localities it is snow white, translucent and compact like Parian marble. Plumbago and mica are very generally disseminated through it. It also contains a great variety of fine minerals imbedded, which will be enumerated in another place.

Local details. One of the most interesting localities for the imbedded minerals of the white limestone, is about fifty rods northeast of Amity meeting-house. On a small knoll, and at the west and southwest base of the knoll, the principal minerals have been found. The limestone is a very coarse-grained rhombic spar, so that rhomboids of two inches on a side are not uncommon. I obtained from this place calcareous spar, rhomb spar, brucite of a beautiful

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* Dr. HORTON, Third Annual Geological Report of New-York, 1839.

† The *Drowned lands* is a large marsh of about twenty miles in length, and one to five miles in breadth, and is the bed of a lake filled with alluvion. It has already been described. The white limestone forms the shore of one of its bays at Amity.

yellow, xanthite, talc, black spinelle, ruby spinelle, coccolite of a rich green color, sphene, scapolite, phosphate of lime, zircon, and bronzite or clintonite.* Granite veins may be seen in the limestone a few rods south or southwest towards the tavern. Granite veins were also seen in the limestone during the digging of the well of the tavern. Another interesting locality is near that first mentioned, a few rods west across the little valley between the ridges. Hornblende (massive and crystallized), hexagonal plates of plumbago, coccolite (red and green), copper-colored mica, and garnet, red brucite, pargasite and idocrase, are also found at the western base of the eastern knoll.

About one mile southwest of Amity, by the road side, is the locality where the large spinelles were found in an aggregate of limestone, spinelle, serpentine, brucite, and crystals of specular iron ore. The rock was partially decomposed, and hornblende crystals were also found there. Some of the serpentine that I obtained at this place was distinctly crystalline.

"About three-quarters of a mile southwest of the above locality, in the middle of a bye-path leading west from the main road, and distant about forty rods from it, are found handsome beryl-colored crystals of *apatite*, associated with a purplish brown *augite*, which is sometimes in distinct crystals of considerable size, but more frequently in granular concretions (coccolite). In the same connection also occurs a snowy white scapolite, not well crystallized, together with crystals of plumbago. These minerals are imbedded in the limestone, in a vein-like cavity." "It is not rare to find, in the limestone, partial veins of scapolite in this vicinity."†

About half a mile north of the last locality, are greyish red spinelles in octohedrons and hemitrope crystals of a large size. The crystals are often coated with a saponaceous or steatitic coating, and present various shades of green, yellow and black. Crystals of serpentine of a tabular form, and in the incipient stages of decomposition, occur. Sphene and augite also occur here, similar in aspect to the specimens from Rogers' rock on Lake George.†

A locality about half a mile southeast of Amity, affords brown spinelle in large octohedral crystals. The cavities in some of the crystals of spinelle are lined with small crystals of corundum. The same rare mineral is also attached to grey hornblende in loose masses.†

One mile south of Amity, the spinelles abound, and the mineral called *warwickite* is also found in the limestone at this place. Brucite in large masses may be obtained from the soil where the limestone has decomposed, a few rods farther east.

A locality one mile north of Amity, shows the limestone filled with brucite of various

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* This mineral was first found by Dr. Horton, Mr. John Finch and myself, in the summer of 1828. We conceived it to be a new mineral, and gave it the name of *clintonite*. It was afterwards described by Mr. Finch, under the name of *bronzite*, which he then believed it to be. It was afterwards called *seybertite*, and afterwards *holmsite*. As one of the original discoverers of the mineral, I claim the name originally given, in honor of our distinguished statesman, scholar, and man of science, De Witt Clinton. Another mineral, since the above note was written in 1838, has been called *clintonite*, but this has the priority. Mr. Finch's article, describing the mineral, is in the American Journal of Science, Vol. 16, pp. 185, 186.

† Shepard, American Journal of Science, Vol. 21, pp. 230, 231.

colors, black spinelle in hemitropes, magnetic oxide of iron in large rough octohedral crystals, hornblende, and blackish serpentine.*

A locality two and a half miles north of Edenville, affords beautiful groups of crystals of spinelle. The rock in some parts might be called *Spinelle rock*, but contains some carbonate of lime, which, when dissolved out by an acid, brings to view the brilliant large groups of crystals of spinelle. An aggregate of hornblende, mica and limestone, also forms masses of rock in this hill. Crystals of zircon, pargasite, black hornblende, and yellow brucite, also occur here.

At a locality between Mounts Adam and Eve, red and black spinelle, red brucite, augite, green hornblende, idocrase and scapolite are found.

At the southern base of Mount Eve, at an old mine hole, where a deep excavation was once made in search of the precious metals in the white limestone, beautiful crystals of green and brown hornblende are found in the limestone and scapolite. Crystals of zircon are also found in the scapolite. Augite, brucite and spinelle also occur there.

Another locality south of the above, is three-quarters of a mile north of Edenville. It affords fine crystals of the hair-brown hornblende called *edenite*. The crystals are terminated, and imbedded in an aggregate of white limestone and brown mica. The edenite also occurs in loose boulders of limestone a little farther north. Brucite of various colors, pargasite and reddish brown mica occur in the same blocks.

About forty rods north-northeast of the last locality, is a vein of arsenical iron in limestone. The limestone contains massive hornblende and augite. Scapolite, augite and sphene also occur in the immediate vicinity. Arseniate of iron coats the surfaces in the fissures of the ore.

The above *localities*, and an abstract of the remarks on them by Prof. Shepard, is from the American Journal of Science, Vol. 21, pp. 324, 332; and I have added some observations of my own, from memory of the localities. I have visited them all, and a great number of others, where the phenomena connected with geology were better calculated to interest the geologist, and where there was also much to interest the mineralogist; but my notes are lost.

The following remarks, however, by Prof. H. D. Rodgers, on these rocks, their metamorphic changes, and their associated minerals, will supply the same kind of evidence that I have received from personal observation.

"Following the range of the crystalline limestone somewhat more in detail, we shall commence our description of its geological features where it first conspicuously shows itself, in the neighborhood of Amity, in New-York. Here, and for several miles to the southwest, the belts of altered rock occupy a very considerable width, in the valley ranging from Mounts Adam and Eve towards Hamburgh, forming a zone averaging at first half a mile in breadth, but contracting to two or three hundred yards. The crystalline material in its most perfect form does not, however, fill the whole space, but occupies rather a series of closely adjacent parallel bands, most numerous towards the middle and northwestern side of the valley, where

* SHEPARD, American Journal of Science, Vol. 21, pp. 230, 231.

a chain of low irregular ridges usually contain the limestone in the highest state of crystallization. These evidently mark the existence of a series of parallel veins of igneous origin, the intrusion of which into the limestone has obviously caused its alteration. Between the base of the Walkill mountain and the crystalline rock towards the middle of the valley, we usually meet with beds of the formation which evince but a partial amount of change from the igneous action; the limestone retaining more or less of its bluish tint, and presenting only a subcrystalline, or even the ordinary earthy texture. These less altered beds, reposing upon the gneiss of the Walkill mountain, dip towards the northwest. Towards the base of the Pochunk hill, on the other side of the valley, the limestone would seem to have undergone a more extensive alteration. Approaching Hamburgh, the crystalline belt contracts considerably in width. About two and a half miles northeast of that village, we find it occupying a broken chain of long, narrow, irregular ridges of considerable elevation. These range parallel with the base of the Pochunk mountain, separated from it by a tract of low meadow ground, about three hundred yards in breadth. In this belt the altered limestone is in great confusion; the calcareous crystalline matter being mingled largely, in many places, with a white friable sandstone, referable obviously to Formation I.,* the position of which, when it occurs at all, is immediately beneath the limestone. The fused calcareous matter seems in some cases to have penetrated the substance of the sandstone. The height of this ridge or chain of ridges may be stated to average about two hundred feet; the width at the base being not less than a fourth of a mile, and the length rather more than one mile. Besides the mass of altered limestone, these ridges comprise portions of Formation I.,* together with beds of the gneiss, both in a highly disordered and shattered condition, with more than one extensive dyke of igneous matter, the immediate cause, most probably, of these disturbances.

"From the confusion which accompanies all these rocks, none of them can be found, even for a short distance, possessing any regularity of dip. The gneiss rocks of the Pochunk mountain, on the contrary, are distinctly seen dipping steeply towards the valley to the southeast.

"The most conspicuous display of the crystalline limestone is at the two extremities of the ridge which lie nearest Hamburgh. Between these points, towards its central portion, the same ridge contains a large well-known deposit of brown or hematitic *iron ore*, occupying its summit and sides, and penetrating deeply into the body of the hill."

"Separated from the Hamburgh belt of altered limestone, by a spur of the Walkill mountain, there exists another band of the crystalline rock on the Sandpond creek, about one mile and three quarters southeast of Hamburgh. This commences near the southwestern termination of a small knob of gneiss.

"Though highly crystalline, the limestone still retains considerable regularity of stratification, dipping towards the west-northwest at an angle of twenty degrees, being well exposed in a quarry (the property of William Edsall), where it is used for making pure lime. It is

* The Potsdam sandstone of the Geological Reports of New-York.

white, and highly crystalline, and contains disseminated scales of graphite. This line of altered rock ranges southwestward nearly to the turnpike, and is met with again on the road to Sparta, about half a mile beyond the turnpike.

"Between the small knob of gneiss, above spoken of, and the Walkill mountain, to the southeast, we meet with another deposit of brown or hematitic iron ore, a little beyond the termination of the crystalline limestone, none of which, however, is discovered near it."

"To the northeast of this altered belt we trace another, occupying the northwestern side of the Mine hill, east of the Walkill stream, a long narrow point of primary rocks, extending from Pimple hill to within about three miles of Hamburgh. Not far from the northeast termination of Pimple hill, and near the old Franklin furnace, we encounter, in the northwestern side of the Mine hill, next the valley of the Walkill, a narrow belt of common gneiss rock, dipping as usual to the southeast. Reposing upon this, with a conformable dip, is seen a highly interesting mineral vein composed of impure magnetic iron ore, franklinite, garnet, jeffersonite, and several other crystalline minerals, blended, especially near the borders of the mass, with the crystalline limestone, much darkened and changed from its ordinary appearance by the amount of combined mineral matter. Much of this calcareous portion of the vein is pervaded by small granular crystals of the franklinite. The whole vein has a thickness of several feet.

"Immediately east of this metalliferous vein, there rests, in the main body of the hill, a broad belt of the white crystalline limestone, preserving its original, rather steep, southeastern dip. The position of the vein here is therefore, as in the majority of instances in the region, intermediate between the primary strata and the beds of altered limestone, which, notwithstanding the partial fusion and intense heat to which it has been subjected, still furnishes distinct traces of its lines of deposition.

"Towards the eastern declivity of the hill, the crystalline rock prevails in considerable purity, though it is often very free from foreign admixtures, even adjacent to the metalliferous vein. In this latter position, however, it is more frequently mixed with quartz, felspar, sahlite, augite, hornblende, and a great variety of minerals, some of which are common ingredients in the primary strata of the country. In the quartz, and near its contact with the limestone, green spinelle occurs.

"The occurrence of so many of the minerals which are constituents of the adjoining *primary* rocks, both in the intrusive vein itself, and in the neighboring portions of the altered limestone, is a fact of no little theoretical interest, as it leads us directly to views tending to explain satisfactorily the several sources of the numerous and varied crystalline minerals found connected with the changes effected in the limestone.

"At the summit of the ridge there is a seam of quartz rock, presenting some indications of its occurring as a vein in the white limestone. Its nature and origin cannot be proved, for it may be a vein of mineral matter strictly intrusive, or one of the beds of chert, so common in the limestone, or a portion of Formation I., completely fused by contact with the intensely heated metalliferous vein. The confused arrangement and varied aggregation of the altering and altered materials at this place, render it next to impossible to trace the true relationship

subsisting between some of the parts comprised in this curiously heterogeneous belt of mineral matter. The vein in its course to the southwest, undergoes a considerable change in its character. About two hundred yards southwest from the place already mentioned, it appears to consist almost wholly of garnet rock and jeffersonite, some of the latter occurring in enormous crystals, projecting from the face of the rock, but so fissured and readily broken as to render it difficult to procure them entire.

"Further still to the southwest, and nearly opposite the Old Forge, are considerable excavations made in former times for *iron ore*. The ore was far from pure, abounding in franklinite; which, by the manganese and zinc contained in it, seriously interfered with the conversion of the ore into iron. This ore includes, moreover, a considerable proportion of the red oxide of zinc, in some places remarkably pure, being finely lamellated and unassociated with any of the franklinite that generally accompanies it, and which interferes effectually with its reduction into metallic zinc on a large scale.

"Could this pure red oxide be obtained in sufficient quantity, it would probably be better adapted for smelting into zinc than the mixed ore of the Sterling mine, three miles further to the southwest. This somewhat rare ore of zinc, the crystallized red oxide, occupies in company with the crystallized franklinite, a metalliferous vein, or more probably a line of nearly continuous veins, in the crystallized carbonate of lime, extending with occasional interruptions, the whole distance from Franklin to a little beyond Sparta, a total length of more than eight miles."

"From Franklin we may trace the white crystalline limestone continuous to Sterling, about three miles to the southwest. Here we find it lying in contact with a remarkable vein consisting exclusively of franklinite and the red oxide of zinc; the former in crystalline granules, often approaching the octohedral form, invested by a paste of the zinc ore, which frequently constitutes more than one-half of the mass. The position of this vein is on the eastern declivity of a hill of considerable elevation, where it occupies the same intermediate relation to the gneiss and crystalline limestone which was mentioned of the vein at Franklin.

"At Sterling, the metallic vein, where it is visible at the surface, rests with a steep southeast dip *conformably* upon the steeply dipping beds of gneiss, rising in the form of a bold cliff or wall along the side of the hill. Against this wall of ore, and at the base of the hill, repose the beds of the white altered limestone, presenting unequivocal traces of its original planes of stratification, showing the sedimentary origin of the rock. It obviously dips at the same inclination of from seventy to eighty degrees to the southeast, with the vein and the gneiss upon which it lies.

"The metalliferous vein is from eight to ten feet in thickness, and consists of no other minerals but the franklinite and ore of zinc. From its exposed position on the flank of the hill, the ore could be excavated to an almost indefinite extent with a facility unusual in the history of mining operations. Zinc of an admirably pure quality has been prepared from this ore by Mr. Hitz, under the directions of Mr. Hasler, for the manufacture of the brass for the standard weights and measures now making by the latter scientific gentleman for the several custom-houses of the United States, by order of Congress. An economical method for the

separation of the zinc from the franklinite in this ore, still remains, however, a desideratum in practical metallurgy.

"Between Sterling and Sparta, the belt of crystalline limestone is traceable with but little interruption nearly the whole distance, affording in some places specimens of a variegated marble of uncommon beauty. It follows the eastern base of Pimple hill to the southwestern termination of that ridge, and then appears nearly in the same line at several points on the west of the gneiss hills, west of Sparta, and also within a few hundred yards of the town itself. The narrow valley embraced between those hills and the Walkill mountain on the southeast, is, in the immediate neighborhood of Sparta, and for some distance southwest, occupied by the unaltered blue limestone dipping usually towards the northwest.

"About a third of a mile northwest of Sparta, the white crystalline limestone crosses the turnpike road. This is one of the principal localities whence mineralogists have supplied their cabinets with specimens of chondrodite or brucite. A better locality, however, may be seen on the west side of the hill, about half a mile further north, where another exposure of the white crystalline limestone affords crystals of the brucite and grey spinelle in an abundance, and of a quality far surpassing those of any other spot yet discovered in this vicinity. At the same place might be opened inexhaustible quarries of variegated and pure white marble; some of the former promising to be, if polished, of uncommon beauty. Care should be observed, in establishing quarries in this rock, to choose those parts of the belt least shattered by the action to which it has been exposed.

"Between three and four miles southwest from Sparta, on the northwest side of a low ridge of gneiss, we find a very interesting locality of the altered limestone, very nearly in the prolongation of the belt which passes along the southeast base of Pimple hill. This spot is remarkable less for the extent or breadth over which the limestone has been affected by igneous action, than for the strikingly convincing evidence which it affords of the nature of the changes induced in the calcareous rock by the series of igneous veins and dykes which we have been tracing. The ridge itself, along the side of which the limestone has been altered, consists chiefly of a thinly bedded *micaceous* gneiss. Through the summit, or rather on the northwestern flank, which is often abrupt and rugged, there rises a thick granitic dyke or vein of very heterogeneous composition, supporting the steeply dipping beds of gneiss, whose usual inclination is at an angle of eighty degrees to the southeast. The vein, though various in character, and somewhat difficult to describe, owing to the imperfectly developed nature of its minerals, and their complete interfusion, may be characterized as consisting, in the main, of mica in large excess, quartz, carbonate of lime, felspar, and augite. It contains spinelle, sapphire, and green talc, besides several other minerals less distinctly crystallized.

"When we consider the highly micaceous character of the adjacent gneiss rock, through which the matter of the vein must have passed in reaching the surface, and the abundance of the mica, especially of the brilliant golden variety, found so plentifully not only in it, but in the adjacent parts of the altered limestone, we cannot resist the impression that a portion of the primary strata along the sides of the dyke have been melted and incorporated into it, floating, in combination with the other materials, to the surface.

"Immediately upon the western side of this curious vein, and ranging along the base of the hill, occurs the narrow belt of altered limestone. The gradation of change which here exists between the blue and earthy limestone, and the white crystalline rhombic spar, is distinctly traceable as we approach the igneous dyke. In a breadth not exceeding fifty feet, we discover every degree of modification which the rock can undergo by heat. The first intimation which the limestone gives us of its having been subjected to the igneous agency, is its passage from the ordinary earthy texture to a subcrystalline one. We next behold a slight change of color to a lighter tint of blue; and, at this stage of alteration, we notice the first development of the *graphite*, as yet seen only in small but very brilliant scales, which are oftentimes hexagonal. Very soon the mass becomes mottled with white, minutely granular carbonate of lime, the spangles of graphite growing progressively larger. Approaching still nearer to the dyke, the whole rock assumes the white sparry character, and contains, near the line of contact, besides the graphite, several of the numerous crystalline minerals of the vein itself. So completely has the injected matter of the vein been mingled, in many places, with the fused substance of the limestone, that no distinct line of demarcation is discernible between them.

"The series of changes here described may be considered as representing the phenomena in every instance, where superficial deposits have not concealed the vein, the blue limestone, and the intermediate altered belt. The locality above referred to is dwelt on in detail, chiefly because it furnishes a distinct exhibition of each successive stage of the change. The gradation is not more complete at this place than near many other dykes, but it is better exhibited within a small area.

"The invariable occurrence of the graphite in portions of the altered belt remotest from the dyke, and its never existing in more than a very trivial quantity, even adjacent to the vein where the other extraneous minerals are frequently present in great excess, strongly imply that it has been derived from the elements of the blue limestone itself, which may easily be proved to contain an adequate quantity of iron and carbon for the production of this mineral.

"It is not a little curious that, in some belts, the altered rock contains the mineral *chondrodite*, in a precisely similar relation as to the degree of crystallization of the mass, and proximity to the vein of igneous matter; that is to say, when it first appears in the portions of the crystalline belt remotest from the line of injected minerals, it is in small imperfectly developed nuclei, which grow larger and better formed as we approach the quarter of more intense igneous action, but which, like the crystals of graphite, usually remain but sparsely disseminated through the rock. Showing a strong analogy, in its mode of distribution through the substance of the white limestone, to the nuclei or geodes of epidote and other minerals seen in the red shales, where these have been baked and altered by the intrusion of dykes of heated trap, the chondrodite seems to claim a corresponding origin to that generally attributed to the epidote, which is regarded as derived, in these cases, from the constituents of the rock itself. To trace the source of the chondrodite upon this hypothesis, we have only to conceive that the injected mineral matter, in an igneous state, was poured through fissures in a limestone, possessing, what is very common, a silico-magnesian character; and the well known tendency to the production of specific mineral combinations, in a mass whose

particles are in a state of at least semifusion, and therefore free to obey their several affinities, will readily explain the formation of these insolated crystalline nuclei. The mineral chondrodite contains about fifty-four per cent. of magnesia, with about thirty-eight per cent. of silica, besides trivial proportions of oxide of iron, potash, fluoric acid, and water. These suggestions respecting the origin of the chondrodite, receive support from the fact that this mineral prevails in its usual uniform and moderate proportion through considerable ranges, longitudinally, of the altered limestone, even where not immediately contiguous to the injected veins; while in other parallel zones of the crystalline rock, it is almost wholly absent. Thus, in the chain of sparry limestone which stretches at intervals from Sparta towards Lockwood, we find it almost constantly present, though never but in moderate quantity.

"From several chemical analyses of the sparry, rhombic varieties of the rock containing only *graphite*, and of the white irregularly crystalline kinds enclosing the chondrodite, we have still more conclusive evidence tending to settle this interesting point.

"Resuming our progress towards the southwest, we next meet with a succession of detached ridges of the altered sparry limestone, in the valley between the Walkill mountain and the primary ridges southwest of Sparta; the latter tract of gneiss separating this belt from that previously described. These ridges first appear nearly four miles southwest of Sparta, at the extremity of an extensive meadow, and range towards Lockwood. They are four in number, the shortest being about one hundred yards long, while the longest exceeds a fourth of a mile. Their width is between two hundred and three hundred feet; they occupy one general line; but between their extremities is usually a space of from half a mile to a mile of primary strata, whose prevailing dip is towards the southeast, though under circumstances of great irregularity.

"The white altered limestone of these ridges is rather in the condition of an amorphous crystallization, than in the form of rhombic spar. Such is the case at Franklin and Lockwood. It is in fact a coarse granular white marble imbedding many of the rare and beautiful crystalline minerals found at Amity and Franklin; we may mention brucite and green spinelle of uncommon purity.

"Notwithstanding the prodigious extent of igneous action to which the limestone has been evidently exposed in these belts, manifested by the width of the space over which a total modification of the rock has been effected, we still discern a very distinct stratification, the beds dipping steeply towards the southeast.

"In the same line with this series, and about one mile and a half further to the southwest, occurs another somewhat shorter belt of the altered limestone, a little beyond Lion pond. The length throughout which the limestone has been modified, does not exceed two hundred or three hundred feet, and the width of the belt is not considerable. The locality is nevertheless an interesting one; for we find well exposed, within a tract not more than a fourth of a mile wide, first, the primary strata on the southeast; then the sandstone, F. I.;* next the blue

* The Potsdam sandstone of the Geological Reports of New-York.

limestone, F. II.* passing into the sandstone, and assuming near the passage a clear reddish hue; and lastly, the belt of altered limestone in contact with a small elevated hill or dyke of felspathic sienite, the cause of the altered structure of the calcareous rock. All of these stratified masses, the gneiss, the sandstone, the blue limestone, and the white crystalline belt, dip alike towards the northwest at a gentle inclination. Graphite is here present as usual in the calcareous mass; which besides contains other minerals.

"Portions of the altered rock are coarsely crystalline, though other parts of it are more minutely granular. A variety which is variegated with numerous blue shades of plumbaginous mineral, might evidently, from its susceptibility of a good polish, be employed as an ornamental marble.

"Between the sienitic ridge here spoken of ,and another lying a short distance to the north, there occurs another smaller belt of the altered limestone, deeply buried between the primary rocks. At this spot some enthusiast in search of mineral treasures, expended at a former day no inconsiderable amount of time and labor, in excavations for silver ore in the sparry limestone.

"West of the last mentioned point may be seen, by the side of Panther pond, another still more unimportant exhibition of the altered sparry rock, not deserving of a special description."†

Mr. Nuttall, one of the most ardent naturalists of the age, and who has observed the geology of North America more extensively than almost any other individual, has described the limestone of the range under consideration. Describing the rocks near Mr. Fowler's house at Franklin, he says, "The crystalline calcareous rock, which here alternates with granitines of felspar and quartz, or with beds of sienitic granite, disappears, and a confluent grauwacke, almost porphyritic, and contemporaneous apparently with the other formations, appears directly overlaid by a bed of leaden minutely granular *secondary* limestone, containing organic remains of the usual shells and corallines, and layers of blackish hornstone or petrosilex. This rock, as well as the grauwacke *beneath*, presents disseminated crystals of blue fluate of lime. In the limestone the cavities are sometimes very numerous, and lined both with pseudomorphous masses and cubes of blue and white fluate and quartz crystals.

"Thus we have here before us, as at Lake Champlain, the novel and interesting spectacle of an union of every class of rocks, but *passing* decidedly *into each other* as if almost *contemporaneous!* If they are not contemporaneous, how do they happen to penetrate each other by veins? Why do they present similar mineral substances; similar organic remains? Why do the same relics of plants occur over the anthracite of Rhode-Island (which is occasionally penetrated even by seams of asbestus), as over the bituminous coal-fields of Pittsburgh and Richmond? Why are the beds of coal at Richmond in Virginia penetrated by *veins of granite?*"

"Are, in fact, those supposed epochas of time, believed to have intervened between the production of strata, anything more than an imaginary distinction of formations really allied, and as strictly dependent on each other as the members of the same formation? The grau-

* The Mohawk limestone and Calciferous group of the New-York Geological Reports.

† Final Report of the Geology of New-Jersey, by Prof. H. D. Rodgers, pp. 166, 176.

wacke and *red* sandstone, we perceive, contain organic remains; the grauwacke imperceptibly blends with the granitines, sienites, and greenstones of the Highlands. The hornblende rock and its metalliferous deposits unquestionably pass into gneiss; gneiss is foliated granite. Where then are we to seek for permanent distinctions?" *

Science is yet in its infancy. It is as yet difficult to say what rocks are primitive, what transition, etc., except where their superposition and fossils can be traced. Most of the rocks that we have been accustomed to call primary, and consider as old as the foundation of the world, are found to have been sedimentary rocks, and since modified and rendered crystalline. Mr. Nuttall was probably the first to suspect that the white limestone of Orange and Sussex counties was not a primitive rock, and that the rocks of the Highlands are of the same age. I must, however, object to his inference that the epochs of time indicated by stratification are imaginary, although in a limited sense I agree with him.

I think few can examine this belt of limestone in Orange and Sussex counties, and trace its metamorphoses from the blue and calcareo-siliceous limestones, and the granular quartz rock and potsdam sandstone variously modified, and their association with sienitic, granitic, and hornblendic aggregates, without being convinced that they are metamorphic rocks; and that they have been brought to their present form by the agency of heat; and that this has given a sufficient mobility to the particles of the rocks, to permit them to obey the laws of chemical affinity and of crystallization.

(b). *Metamorphic limestones of the Highlands, of Orange and Rockland counties.*

This rock is the same in its general characters and imbedded minerals as the white limestone of Warwick. It forms long narrow belts associated with granite, sienite, hornblende and augite rocks, and some anomalous aggregates. Dr. Horton, to whom was confided the examination of Orange county, describing this rock, says: †

"This rock has a distribution of some extent in the county. Beginning on the Hudson river, it is first observed half a mile northwest of Fort Montgomery. It is here several rods in width, and can be traced two miles northeast from the line of Rockland county. It here lies confusedly, the stratification indistinct, rising into short and broken ledges; it is white, and everywhere full of plumbago, pyrites of iron, boltonite and serpentine; so much so, that it can scarcely be recognized as a white stone. It is, wherever noticed in this vicinity, small, crystalline, and very hard for this rock. This stratum or bed takes the direction of the granitic rocks, in which it is embraced; the line of bearing being northwest and southeast nearly."

Local details. "Proceeding from this point directly northwest, six or seven miles along the gorge through which Fort Montgomery creek reaches the Hudson, we reach another bed of this rock. This point is a few rods northwest of the Forest of Dean mine. Here this

* American Journal of Science, Vol. 5, p. 247, 248. † Third Annual Geological Report of New-York, 1839, p. 139, 141.

rock, interstratified with the granitic and hornblende rocks, occupies a breadth of nearly or quite a mile, being wider than where seen at any other place.

"From this point, it may be traced northeast by the way of Little Round pond, northeast corner of Bog-meadow pond, southwest by the way of Popelo's pond, and the brook from the Two ponds to Greenwood furnace; thence, with some interruption where it crosses the Ramapo, by the east side of Duck-cedar pond, to the New-Jersey line.

"In all this extent, it frequently disappears and again reäppears, after having apparently been cut off by the granitic rocks. It is seen in some places only a rod, or even less in breadth. In many places it is seen in contact with the granite, the gneiss and hornblende rock; sometimes *between* them, sometimes *above* them, and sometimes *beneath* them. It is *not* stratified. In all this extent, which is about twenty miles in a straight line, it is confined between certain limits, and never appearing northwest or southeast of given lines, which may be about a mile distant from each other. It is generally quite narrow, and occasionally it is *cavernous*. Its bearing is southwest and northeast. Its prevailing colors are white and red; much of the red is flesh-red, and coarsely crystalline, forming a handsome calcareous spar. It everywhere contains imbedded minerals; those which particularly distinguish it in almost every locality, are what is believed to be the *boltonite* of Shepard, and small black spinelle. What I suppose to be *boltonite*, has hitherto been called *brucite*, which it resembles in some respects. The Mineralogist of the Survey will determine to which species it belongs. This rock also contains beautiful pargasite, sahlite and coccolite; also crystallized augite, scapolite, zircon and sphene; also serpentine and plumbago.

"A few trap dykes are seen cutting obliquely across this rock, one of them is partially exposed at the Two ponds in Monroe, and contains imbedded crystals of hornblende. Three others are visible at the Duck-cedar pond, and of them finely exposed. It is here seen cutting the limestone precipice perpendicularly downwards fifty feet, and running nearly east and west. The trap rock is perfect greenstone. A few rods from the southwest end of Popelo's pond, where the stream enters it, this rock forms a perfect natural bridge. It is used as such, and one might cross it without being aware, unless the noise of the brook aroused his attention. The breadth of this bridge across the stream is fifty feet, and its length up and down the stream seventy-five or eighty feet. Hornblende rock supports the arch on one side, the other is covered by soil, but it is believed to be granite. This space is spanned by the lime-rock. The water, at present, fills the concavity below, so that I could not see through; but in times of drought, people pass through it.

"This limestone is also met with half a mile southwest of the Queensborough forge, very much resembling that at Fort Montgomery, and containing the same substances imbedded in it. It is here of very limited extent, being confined to a few small elevations of a few rods in extent."*

A bed of limestone containing serpentine, was found in Rockland county. It is on the

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* Third Annnal Geological Report of New-York, 1839, pp. 139, 141.

immediate shore of the Hudson river, about one or one and a half miles below Caldwell's landing, and above Tompkins's quarries. Prof. Cassels describes it as four or five rods wide, measured across the strata, which are rather thick layers and blocks than strata. It is stated that blocks of any reasonable size can be quarried here, free from cracks and flaws. It is of various shades of color, from a deep spotted green to a beautiful bluish white. It is generally free from pyrites, but some blocks contain crystals of this mineral. The occurrence of this mineral would injure it for sawing and polishing, but Mr. C. reports that most of the quarry is free from it, and that the verd-antique marble from this place takes a high polish. The quarry is on the shore, and vessels can come directly along side. The quarry belongs to Sampson Marks, esquire.

I will add some of my own observations on some of the localities mentioned by Dr. Horton, and some others belonging to the same rocks in Orange and Rockland counties.

The bed of limestone described by Dr. Horton, near Fort Montgomery, is traversed by one of the transverse lines of fracture and upheave that have produced great derangements of the strata. The direction of the line of bearing of the strata affected by this line of disturbance is N. 20° W. from the house of Mrs. Pell, below Fort Montgomery. The strata are much confused over a breadth of half a mile to a mile, from northeast to southwest. The limestone on the hill southeast of Peekskill, that has been mentioned as ranging in a southeast and northwest direction, is also situated on this line of disturbance, as also the southerly part of Anthony's Nose mountain.

The bed of limestone near Fort Montgomery can be traced at intervals about three miles to the north-northeast. There are numerous excavations that have been made in it, in search of the precious metals, but no metallifereous minerals were seen at any of these localities but pyrites, magnetic pyrites, and grains of magnetic oxide of iron. Augite, sahlite, mica and hornblende, are the common associates of the limestone, and a slaty pyritous gneiss is the rock that is most commonly adjacent. At a locality near Mr. Potter's, one mile northwest of Fort Montgomery, the *pyritous limestone* has been blasted out to make *copperas!* The pyrites here are mixed with white augite, limestone and serpentine. The strata are in great confusion.

A great variety of minerals may be obtained in this vicinity, though not as beautiful as in many other places. Among them may be mentioned pyrites, (both common and magnetic), magnetic oxide of iron, sphene, augite (white, grey and green), coccolite, hornblende, manganesian garnet, limestone (white), verd-antique, serpentine and schorl. *Allanite*, crystallized with brilliant faces, I found there in 1827.

Another limestone bed was observed on the roadside above Queensbury Forge, about four miles from Fort Montgomery. It contains brucite, spinelle, sahlite, coccolite, and glassy green hornblende. About one-half or three-quarters of a mile farther on, another bed of the white limestone, containing brucite, augite, coccolite and scapolite, was observed. Gneiss rocks are associated.

At the Forest of Dean iron mine, six miles west-northwest of Fort Montgomery, an extensive bed of this limestone exists. The extent has been described by Dr. Horton. Some of it

is white, and contains brucite and spinelle; but much of it is of a flesh-red color, and contains grains of white scapolite, green phosphate of lime, and hornblende and some mica.

About two miles farther up the stream to the west-southwest, the iron ore was again seen, and near it the red granular crystallized limestone associated with beautiful massive and laminated scapolite, more beautiful than any I have seen from other places. Crystallized augite and sahlite in fine terminated crystals, also occur there. The position of the rocks at the Forest of Dean mine, are represented, as far as observed, on Plate 5, fig. 9. The red limestone is found farther to the north-northeast, at several localities between the Forest of Dean and Round pond.

A few rods southwest of Round pond, four and a half miles southwest of the West-Point Military Academy, is a locality of the limestone under consideration. It is now perhaps scarcely exposed to view, being mostly covered by soil. It was finely exposed some years ago, by the earth caving down into a cavern in the limestone. Lieut. Prescott and others had the earth and rock dug out to expose the opening into the cave, which has already been described on pp. 36, 110 of this volume. The limestone is white and flesh-red, and contains brucite (sometimes in imperfect crystals), small but brilliant crystals of black spinelle, hexagonal crystals of mica, augite, hornblende, and phosphate of lime. The same kind of limestone but far more impure, may be seen at the Bear Hole, a short distance farther southwest, about a quarter of a mile from the Round pond; but it is so mixed with other minerals at this place, as to be scarcely recognized as a limestone without close examination. The surface is warty and uneven, from the enclosed minerals projecting beyond the general surface of the rock. This is due to the action of the weather, removing the carbonate of lime more rapidly than the enclosed minerals. Granite and gneiss are the associated rocks. Hornblendic and augitic rocks are common in the vicinity.

The locality on the northeast corner of Bog meadow, or Reservoir pond, a mile northeast of the preceding, I found in 1825, when exploring those wild mountains. A fine spring issues from the base of the rock. The limestone is a beautiful flesh-red, very coarsely crystalline, so that large rhombic crystals can be obtained by cleavage, and richer in color than the red limestone of this character from any of the other localities from which specimens have been obtained. It contains, in some parts, dark green imbedded grains of augite or hornblende. Adularia and glassy felspar are common in the granite rocks of the vicinity. The locality is not at the northeast corner of the pond, but at the northeast extremity of a small bay of the pond on the east side.

Many localities of the white and red limestone containing brucite and spinelle, were examined in Monroe, associated with quartzose gneiss, micaceous gneiss, felspathic granite, augite and hornblende rocks; but I will describe only one more, which is somewhat remarkable in consequence of the limestone being traversed by *dykes and interlaminations of greenstone*, and the lateral heaves or faults to which the rocks have been subjected. The position of the rocks was intended to be represented on Plate 5, fig. 11. One portion represents the topography around the locality, which is about a quarter of a mile southeast of the southern extremity of

Duck-cedar pond,* a few rods east of a little swamp.† The lower part of the figure illustrates the appearance of the rocks as seen at one part of the cliff, which is perhaps forty feet high above the debris at its base, and shows the interlamination of the trap or compact greenstone between the limestone beds, the position of the granite on one side of the limestone, and the gneiss rock on the other. The right-hand part of the figure is intended to show a ground plan of the position of the rocks, with the lateral faults to which they have been subjected along the transverse lines; but by being badly copied, the shading or coloring by which the different rocks in each of the heaved masses was distinctly recognized by the eye has been omitted. The left-hand compartment of each of the three masses is granite; the second, limestone; the third, trap; the fourth, limestone; the fifth, trap; the sixth, limestone; and the seventh and succeeding ones are gneiss in nearly vertical strata, ranging N. 20° E., as represented in the section. A mass of the adhering limestone and trap from this locality, is placed in the State Museum of Natural History at Albany. The junction of the two rocks is a perfectly defined line, one nearly black, the other white; and there is no blending of one into the other, but both are perfectly characterized up to the plane of contact. At the locality, these different rocks are *as* perfectly defined for many feet in the face of the cliff. The minerals observed in the limestone at this place, are crystallized mica in hexahedral prisms, green spinelles, hexagonal scales of plumbago, sphene, and sahlite. The sphene is very abundant in some places at this locality, and the specimens look so much like those from Rogers's rock near Ticonderoga, that they could not be distinguished. The sphene is imbedded in a green augite, with scales of plumbago.

(c). *Metamorphic limestones of the Highlands of Putnam county.*

These are similar to those described in Orange county, only spinelle has not been recognized in them, and brucite is not common. Serpentine, augite and asbestus are more common, and garnet is more common in the associated rocks.

Local details.—1. Limestone was observed about one and a half miles south of Putnam court-house, on the farm of a Mr. Townsend, at two old mine holes, where some have supposed that silver, and others that marble was the object of exploration. It is scarcely necessary to add, that no traces of silver ore could be distinguished. Both these excavations are in a bed of limestone about thirty rods apart. The bed is narrow, perhaps twenty feet wide, and is bounded by gneiss on each side; the strata are highly inclined to the east-southeast. Brucite and some coccolite were observed in the limestone of the northwardly excavation. At the other locality the limestone is very white, coarse grained, and contains imperfect crystals of phosphate of lime or green augite.

2. A bed of limestone containing brucite, serpentine and asbestus, is associated with the

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* This pond is called, on Burr's county map, "Truxedo pond."

† By being badly copied, this swamp is represented on the figure as a small pond.

bed of magnetic oxide of iron on Mr. Tilly Foster's farm, two and a half miles southeast of Putnam court-house.

These were the only localities of this kind of limestone seen in the *eastern* part of Putnam county. In the *western*, are two ranges of the same kind of rock. The following localities will illustrate them, viz:

1. A bed of limestone near Anthony's Nose point, six miles south of West-Point, which is seen again farther north-northeast at the old silver mine; also at two places on the shore between that and Cotton rock; also at Cotton rock; near Mr. Arden's; two hundred or three hundred yards southwest of Phillips's mill, east of West-Point; half a mile east of the Highland school; north of Davenport's tavern on the post road; and at Hustis's quarry. This is the westernmost range, and extends from near Anthony's Nose point north-northeast, to near Davenport's tavern; and thence through the valley to Hustis's quarry, about three miles south of Fishkill, a distance of about ten or eleven miles. It has also been seen farther to the north-northeast on the mountain.

2. The second range has not been observed in as many places. It has been seen at the White mine on the Anthony's Nose mountain, three miles east of Fort Montgomery; three miles east-southeast of West-Point, near the post road; on the road from Coldspring to Putnam court-house, near Haight's tavern, five miles northeast of Coldspring; and about half a mile north of Warren's tavern, in Phillipstown. This range is nearly parallel to the other, and nearly similar.

All these localities are supposed to be in the ranges of limestone which are exposed in these various points, and probably in many others.

1. Hustis's quarry is in the western limestone bed above mentioned. Some parts of the hill are granular limestone, and a part is nearly compact magnesian limestone or miemite. Serpentine is frequently intermixed, forming a verd antique marble, which may perhaps at some future time be applied to use. Several fine minerals occur at this locality, which was discovered by Dr. Barratt in 1822. The precious serpentine of this locality is perhaps not surpassed in beauty by that of Newburyport or Easton, or even any locality known. It occurs crystallized distinctly with various modified forms. White coccolite, white augite, diopside, sahlite, phosphate of lime, amianthus, asbestus, pearl spar, pyrites, chromate of iron, magnetic oxide of iron, and various other minerals occur at this locality. The mass of limestone at this place forms a bed twenty to fifty feet thick, resting against granite or sienite, and gneiss containing red felspar and some epidote, on the west, while a stream flows at the base of the hill. Prof. Beck, speaking of this locality, says,

"In a bed of white limestone running parallel with the granite, and which is of small width, and is situated about a quarter of a mile from the New-York road, we have the following minerals, viz: Precious serpentine, of which there are several varieties. The first, has a conchoidal fracture, and presents various shades of green and yellow, and is variously disseminated through the limestone and other minerals. 2. A slaty variety, having a dark green color; it sometimes breaks into rhomboidal prisms, and is very hard and compact.

3. A slaty variety of a greenish white color, is harder than the preceding, and is fusible upon the thin edges by the blowpipe. This last seems to approach jade or saussurite in its characters, but its peculiarities are probably owing to the admixture of some other minerals, as all these varieties seem to pass into each other by almost imperceptible gradation.

"Of the magnesian carbonate of lime, several forms occur at the locality in question. There is a thin stratum which is snow-white, very close grained, compact, and has a semi-opaline appearance. It is sometimes described under the name of *gurhofite*, from its having been first found near Gurhof in Austria. According to my analysis, its composition is as follows, viz:

Silica	6.50
Carbonate of lime	66.75
Carbonate of magnesia	26.50

"Other specimens of this mineral have fibres of asbestus running through them, and they sometimes have a bluish tint, a slaty structure, and contain crystals of bronze yellow iron pyrites.

"Asbestus, especially in the amianthoid form, is indeed largely mixed with the minerals already noticed. The beautiful silky fibres which run through the serpentine and magnesian limestone in various parts of this ridge may belong to the picrolite of the more recent authors."*

2. The bed of limestone northwest of Davenport's corners, which is on the post road five miles northeast from Coldspring, is similar to that at Hustis's, but not as beautiful, and does not exhibit the beautiful minerals of that locality.

3. This range of limestone crosses the road about one hundred or one hundred and fifty yards west of the locality of laumonite and stilbite in Phillipstown, about three hundred yards west of Phillips's mills, and one mile and a quarter east of West-Point. It is white, and highly charged with grains of magnetic oxide of iron. Granular hornblende, like coccolite, also occurs with the limestone. Hornblendic gneiss and micaceous gneiss, containing pyrites and scales of plumbago, also occur associated.

4. This bed has had excavations made in it, in two or three places between the locality above described, and where it reaches the shore of the Hudson about one mile and a quarter southwest of Mr. Arden's; and every place where it was examined, showed imbedded grains of magnetic oxide of iron, and in some places imperfectly characterized brucite and serpentine.

5. The "Cotton rock," as it is called, is at the junction of this bed of limestone with dial-

* Prof. Beck,.Fourth Annual Geological Report of New-York, 1840, p. 86. This locality is the one mentioned in Robinson's Catalogue of Minerals, pp. 145 and 295. It is extremely rich in very beautiful minerals. Phillipstown is a large township, in which there are many interesting localities, which I suppose will be mentioned in the Mineralogical Report by Prof. Beck. There is probably no individual so well acquainted with them as myself, having for twelve years lived at West-Point, and visited them frequently with my mineralogical classes from that institution, and frequently found new ones in our explorations. A list of them was furnished to Dr. Horton for Dr. Beck.

lage and hornblende rocks. The limestone is extremely impure from contained minerals, so that it would scarcely be recognized as limestone from its external aspect, when weathered, by one not familiar with all the protean forms of this rock; the calcareous matter being removed to some depth, and the imbedded mineral substances remaining to form a crust of some lines or even inches in thickness exterior to the sound unaltered rock. Granite occurs in the cliff a few yards to the east, which contains imperfect crystals of black tourmaline.*

6. An outheaved mass, as it is supposed, of this range of limestone, occurs about a mile north of the last locality, near the Beverly dock (the point from which the notorious and treacherous Arnold made his escape). This bed of limestone, which is small, lies transverse to the general direction, viz. northwest and southeast. The limestone is colored with serpentine, and contains plumbago; but some of it is of a pure snow white, strongly translucent, and varies in texture from coarse crystalline to compact, like the finest alabaster. The white is much intermixed with augite and quartz, so that specimens for the cabinet can be obtained showing the characters indicated, but not large masses. The associated rocks are micaceous pyritous gneiss, and grey augite containing hexagonal plates of plumbago. A vein of pyrophyllite, six inches to a foot wide, traverses the grey augite rock.

7. Some distance below the Cotton rock, perhaps one quarter to half a mile, the limestone bed that we have been tracing, forms the shore for some rods. The same minerals are found here as at many other parts of the bed, viz. magnetic oxide of iron, serpentine, and augite and hornblende in the vicinity, associated with granite and gneissoid rocks. A little farther south the limestone has an old mine hole in it, a little southeast of a small bay of the river shore, where the rock contains much magnetic oxide of iron.

8. From this place, the limestone ranges south-southwest towards Anthony's Nose point. This part of the range is perhaps of more interest to the geologist than any other portion, and particularly the tract of land between the "old silver mine," as it is called, and the Hudson river, about a quarter of a mile in width. The limestone and all the associated rocks here, have been subjected to metamorphic agency in a high degree.

The limestone lies at the base of the hill, adjacent to a granitic rock. It is white, highly crystalline, contains much mica, plumbago and various mineral substances. The plumbago is generally diffused in minute particles, but in some places is so abundant as to give a bluish tinge in streaks through the rock. The resemblance of this mineral thus diffused to the sulphuret of silver in minute particles, its softness and lustre, led to the idea that silver ore was abundant at this place.

This mine was opened in ancient times, for what purpose is not known. Stalactites are found in the adit level, which is two hundred yards long, and old tools with the handles rotted

* The Cotton rock is a noted place in the Highlands. It is on the shore of the Hudson, in Phillipstown, between high and low water mark, about three and a half miles below West-Point. The rocks here are impure verd antique (composed of limestone and serpentine, with brucite and other minerals imbedded), serpentine with diallage and veins of asbestus and delicate silky amianthus, diallage rock, augite rock and granite. The amianthus which comes from the veins in the serpentine, has the appearance of cotton or of raw silk, and has given rise to the name "Cotton rock."

out have been found in it. It was reöpened some years ago, with the hope of getting silver; the man who worked it having been told that the scales of plumbago in the rock were sulphuret of silver. He is said to have spent all his property, and to have died in a mad-house.

Sphene and zircon are occasionally seen in the augitic and calcareous rocks at this place, but they are not common.

The most interesting mineral substance in a geological point of view, found at this old mine, is quartz. It is strongly translucent, almost transparent like hyalite, in irregularly round masses from the size of filberts to that of an egg. They seem to have been melted to assume their present form. The first public notice of such facts, so far as I know, was by Prof. Emmons, in the Second Annual Geological Report of New-York, 1839, p. 202. I had observed the rounded, apparently fused quartz at the opening next the marsh, near the south end of the adit level of the "Old silver mine," in 1825; but did not consider it of any special importance as connected with the age of these rocks, until the subject was brought before the public by Prof. Emmons. The spinelles of some localities in Orange county have their angles rounded, and contain spherical cavities, apparently produced by the same cause; and the crystals of phosphate of lime, sent me by Dr. Crawe and Prof. Gray, from St. Lawrence county, have their angles rounded, and contain cavities which seem to be referable to the same agency that has caused the crystallization of the limestone, and the formation and crystallization of the plumbago, and various minerals in these rocks.

The rocks at this locality of the "Old silver mine," are well worth studying. The rock next the limestone on the west of the adit, is composed of augite and manganesian garnet; sometimes one, sometimes the other predominating. Both are crystalline, and sometimes exhibit perfect crystals. The garnet and augite frequently assume the granular form of colophonite and coccolite; red for the first, and green, brown, and purple for the latter. The rock is very heavy, and very similar to some of the beds at Rogers's rock on Lake George.

The rock farther west, is a gneissoid silico-felspathic rock, containing in many places magnetic oxide of iron in grains, and in small strings and veins parallel to the strike of the rock; also schorl in masses of quartz, and sometimes crystals of allanite like those near Fort Montgomery.

Still farther west is a range of limestone, very similar to that at Cotton rock, but purer. It contains an abundance of imperfectly characterized brucite. Gneissoid rocks intervene between this bed and another of limestone seen still farther west, which has the general characters of verd-antique, being composed principally of limestone and serpentine; but it contains other minerals that are hard, and would prevent its being sawed easily. This rock is seen at the south point (called Marble point), and a few rods south of the north point of this neck of land. Granite is frequently seen interlaminated among the strata described, which are about vertical. The gneiss along the shore between the two last masses of limestone, and west of the last mass described, along the shore, contains pyrites, and by its decomposition gives a reddish tinge to the rocks. The same character, and arising from the same cause, is seen in the slaty and micaceous gneiss along the shore, most of the distance from this place, north-northeast to Gouverneur's landing opposite to West-Point.

The *Second range* of limestone, a mile or two east of the one we have been describing, ranges about parallel, and nearly as great a distance.

1. The "White mine," as it is called, is the most southern point at which the limestone of this range, as it is supposed, was seen. It is on Anthony's Nose mountain, about three miles east of Fort Montgomery. The limestone is white, highly magnesian, and contains some carbonate of iron, and perhaps might without any impropriety be called brown spar. It is crystalline and sometimes compact, and contains granular magnetic oxide of iron. It is associated with augite and granitic rocks.

2. Another locality of this rock is about two miles to the north-northeast, near the old post road, at a reputed lead and tin mine. The rock is limestone with some serpentine imbedded, and contains grains of the magnetic sulphuret of iron. Near this place, where the lead is said to have been formed from the ore in the soil by burning brush-heaps, the soil is red, as is so commonly the case where the calciferous sandstone has been upturned and partially altered. The same limestone is seen still farther to the north-northeast, on the hill, but was not particularly examined. The same silico-felspathic gneissoid rocks, and pyritous micaceous gneiss, as described near the "Old silver mine," occur in this vicinity, and the rocks are in some places very much confused.

3. The limestone near Haight's tavern, is similar to that described above.

(d). *Metamorphic rocks of Washington county.*

The metamorphic limestones of this region are similar in their general characters to those described in Warwick and the Highlands, except that brucite and spinelle are rarely found in them. It is generally a coarse, white, crystalline limestone, containing various imbedded crystalline and amorphous minerals, the most common of which are plumbago, augite and hornblende. Hornblende, coccolite and plumbago are the almost *constant* associates. Scapolite is not uncommon. It is very similar to the beds of white granular limestone in Warwick and Monroe in Orange county, and I suppose to those of St. Lawrence county, but it does not contain the various beautifully crystallized minerals (so far as I have seen) that exist in those rocks. In some places the limestone is so much intermixed with other materials found in the gneissoid and granitic rocks, that without close examination it would not be suspected as a limestone. Quartz is frequently found in it, transparent or translucent, with irregular, rounded forms, as if it had been partially melted. Many localities that I have visited show that it has been softened, if not melted. The descriptions and diagrams of the limestone in St. Lawrence county by Prof. Emmons, leave no doubt that it is an injected rock in some localities, and I have seen examples as striking and as demonstrative of this fact in the primary mountain region of Washington county.

There is a locality to be seen on the road between Mount Hope furnace and the iron mines south, that will leave little doubt of the rock having been injected in a fluid state.

In another locality about one or one and a half miles from Fort-Ann to Whitehall, a cliff of the white limestone is exposed on the road-side, and a mass of stratified hornblendic gneiss is distinctly seen imbedded in it. This last example is adduced, not so much for evidence on

the point of former fluidity, as on account of ready access on a public road by which the stages pass daily. Here are also rounded grains of quartz, and scales of plumbago* are seen with augite and other minerals. Numerous localities might be referred to. They are indicated on the geological map of the county. There are many in Putnam and Fort-Ann. Some of the limestone beds have been mentioned as evidently injected, or at least have been fluid, or partially so. Prof. L. C. Beck found white limestone, that undoubtedly belongs to the metamorphic rocks in Washington county, in Fort-Ann.

"At Shelving rock, about twelve or thirteen miles north of Caldwell, a belt of white limestone stretches through the granitic or mountain rocks. In this, nodules of serpentine were found, with fine fibres of amianthus running through them in various directions. In another part of the same bed, the variety of this mineral called *steatite* occurs; as also tremolite, a common associate of the above, in small quantity. A similar belt of white and very crystalline limestone was observed about three and a half miles south of Shelving rock, on the farm of Mr. Samuel Phelps, in the town of Fort-Ann, Washington county. Here we also noticed dark colored serpentine, pyroxene and common garenet, but the specimens were too imperfect for cabinet exhibition."†

There are other beds of this limestone that I have scarce a doubt are metamorphic rocks, once beds of the Mohawk limestone, now altered rocks, partaking of the character of primary rocks, and interstratified at high angles of inclination with gneissoid and granitic rocks. Examples may be seen north of Fort-Ann, along the western side of the spur of mountains that lies between Wood creek and the valley that leads to South bay of Lake Champlain. The white limestone and granite were seen in contact in large beds, and the grey and blue limestones of the Champlain division (the Calciferous sandstone and Mohawk limestone), within a few rods, where they had been but partially uplifted, but not brought in contact with the granitic rocks.

Beds of the white crystalline limestone were observed in many places on the tract of mountains in Fort-Ann, between Lake George and the valley leading from Fort-Ann to South bay of Lake Champlain, and various others were mentioned to me in Putnam, similar in character, which I did not examine.

The white limestone is frequently mixed with mica, augite, etc., like that of the Highlands and Warwick, and it has undoubtedly the same origin. In the *Warwick valley*, the limestone *can be easily traced through all the changes from a fossiliferous, to a crystallized white limestone, containing crystallized minerals and plumbago.* In the *Highlands and in Washington county*, the limestone is the *same in character, containing the same minerals, and associated with the same rocks, apparently exhibiting a still higher degree of change*, but rarely giving any evidences that can be definitely adduced as showing the *gradual change* from the *fossiliferous* to the *crystallized* limestones. The evidence that we *can* adduce, is,

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* A small vein of plumbago was pointed out to me by the proprietor, near this mass of limestone; but it is too thin to be of any use.

† Prof. Beck, Fifth Annual Geological Report of New-York, p. 14.

1st, the similarity to those of Warwick; 2d, the similarity of contained minerals; 3d, the similar associated rocks; and 4th, the evident influence of high temperature.

Metamorphic Quartz Rock.

About two miles north of Galway, is a mass of quartz rock dipping at a small angle to the south, reposing on gneiss and granitic rocks. It was but slightly examined, but from what was seen, and from specimens obtained afterwards by Cadet Seymour, it is presumed to be a metamorphic rock. It occupies the position of the Potsdam sandstone. The specimens obtained from this mass vary in texture, from the perfectly characterized Potsdam sandstone, to perfect greasy and milky quartz, colored in some places reddish by the oxide of iron.

Steatite in Putnam and Dutchess counties.

This substance, in an impure form, has already been described as occurring at the locality of hydrous anthophyllite in the city of New-York.

Another locality was seen near Peckville, a little north of the line of Putnam county, and within Dutchess county. It is there intermixed with serpentine, and although abundant, and quarried in large blocks, it was found difficult to saw it well, in consequence of the different degrees of hardness of the steatite and serpentine. It is beautifully spotted and clouded; and as steatite indurates by heat, it is possible that it may at some future time be wrought as an ornamental stone. Some of the masses of steatite are very pure, soft and easily wrought. In some parts of the bed the rock is granular, or scaly talc, either pure, or traversed in every direction by crystals of actynolite.

Another locality was seen in Phillipstown, Putnam county, on a Mr. M'Cabe's farm. It is near the serpentine rock before described as eight or nine miles north-northeast of Peekskill, and half to three-quarters of a mile east of Horton's pond. The rock here graduates through every variety of aspect, from talc through steatite to serpentine. I did not see proper soap-stone or steatite rock adapted for useful purposes, *in place;* but was assured that large blocks had been dug there, and that there was an abundance of it. I saw slaty steatitic rock *in place*, and small masses of beautiful steatite scattered over the ground. Good quarries of this rock are well known to be very valuable. The blocks are worth twenty dollars per ton in market. This bed graduates on the east into serpentine rock.

ORES FOUND IN THE CHAMPLAIN, TACONIC AND METAMORPHIC ROCKS.

The principal ores are,

1. Iron ore, Limonite (Hematite).
2. Lead ore (Galena).
   Zinc ore (Blende).
   Copper ore.
   Silver ore.
   Cerium.

1. Limonite, or Hematite ore beds.

The beds of this iron ore are very numerous and extensive, and do not perhaps yield, either in quantity of ore or value of the product, to any other equal territory in the world. The beds of this ore seem to be confined to the valleys of the Metamorphic and Taconic rocks, and are almost uniformly associated with talcy slate on one side, and limestone on the other.

Limonite in small quantities, under the forms of compact brown oxide of iron, hematite and bog ore, occurs in many places in Putnam and Westchester counties. The loose masses scattered over the surface of the earth, seem to indicate important beds in Putnam county. If surface indications are worthy of notice, a bed of hematite and brown iron ore will probably be found in the hills near the county poor-house in Putnam county.

Local Details.

Ackerman's mine. A bed of hematite, of excellent quality, as far as the eye can judge, occurs on James Ackerman's farm, about one and a half miles north of the county poor-house, and four or five miles east-northeast of Tarrytown, in Westchester county. Thirty tons of the ore were dug in 1837, and carried to the furnace at Coldspring, Putnam county. It had not been used in September, 1838, but it will undoubtedly make good iron. There is, probably, an extensive bed of the ore. It is associated with white limestone, and this range of rock reaches the banks of the Hudson, a little below Dobbs's ferry. It is possible that beds of similar ore may be found connected with the limestone near the river. Should this be, the ore beds would be valuable, as there would be but little cartage to water transport. An acre of iron ore, only three feet thick, ought to yield the owner at least four thousand dollars, if he leases it to those who dig it for fifty cents per ton.

Bradley's ore bed. A bed of limonite, containing some oxide of manganese, occurs very near the line between Phillipstown and Carmel, in Peekskill hollow, about ten miles northeast of Peekskill. Its thickness is not known. Fifty to one hundred tons of the ore may be seen in

heaps on the ground. The ore was dug many years ago, but it seems to be too siliceous to work well alone in the furnace. By proper mixture with other ores, it might be wrought with advantage. Isaac Lockwood owns a part of the land underlaid by this ore. The right of digging the mine is vested in Nathaniel Bradley of Connecticut, who purchased a large amount of mineral property in the Highlands some years ago. The ore is associated with granular quartz on the east, and probably with limestone on the west, but this latter rock was not seen near the ore beds. These rocks are associated in the above order at the mouth of Peekskill creek.

Staten-island ore beds. Dr. L. C. Beck, in his first Annual Report, described the hematite beds of Staten island.* During the geological investigations of the island, I have observed numerous slight indications of the same ore along the east base of the serpentine hills. The ore beds, where I have seen them, are directly contiguous to the serpentine rock, which contains an abundance of carbonate and hydrate of magnesia, and which seems to have performed the same office in the deposition of the ore as the limestone beds of Columbia and Dutchess counties. Where the rock is fissured and broken up, above the serpentine rock in place, the iron ore is interspersed through the cavities between the masses; but the main body of the ore lies directly above the rock, and forms the soil for a depth of four to eight feet. Much of the ore is in the state of a fine earth of a brown color, but the masses of solid ore have an oolitic structure, composed of aggregated, concentric, spherical concretions, from the size of shot to small bullets. The ore is occasionally found in small quantities near the base of the serpentine ridge. In some instances it was observed fibrous and stalactitical. Mr. Hazzard informed me that beautiful stalactites of limonite had been found on the top of the hill, in digging a well.

Dr. Pierce described the iron ores of Staten island in 1818 (Vide American Journal of Science, Vol. 1, p. 145). Speaking of the ridge, or mountain as he calls it of serpentine, he says, "A mineral of uncommon appearance is observed. It is composed principally of quartz, rough with numerous cells of various forms, in which small siliceous crystals are generally found; the veins or plates of quartz that intersect each other, often embrace talc and oxide of iron, which decomposing, gives some specimens the appearance of volcanic origin. Associated with this cellular ferruginous quartz, brown hematite is often observed." "Its fibres

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* "On Staten island, five miles southwest of the Quarantine, on the road to Richmond village, there are beds of brown hematite of some extent. The ore is sometimes massive, and at others consists of spherical grains of various sizes united by a ferruginous cement, and known by the name of *shot ore*. It often has a shining surface, and appears to be mixed and coated with talc. Brown and yellow ochres are also found here, and are used by the inhabitants as paints. These ores contain twelve or thirteen per centum of water.

"Dungin's mine is situated about a mile and a half north of that just described. The ore is similar to the preceding.

"In consequence of the scarcity of fuel, no furnaces have been erected in the immediate vicinity of these beds. The ore has for several years been transported in considerable quantity to Egg harbor; but whether it is smelted there, or carried elsewhere, I could not ascertain."

assume a variety of shapes; they are observed at Staten island, straight and curved, radiating from a centre, and exhibiting the stalactitical, cylindrical and botryoidal forms, often displaying a black polished surface and glistening lustre. Ferruginous minerals are abundant on the mountain for several miles. A granular oxide, called by the miners *shot ore*, from its being composed principally of spherical grains of various sizes, was often noticed, and appears in some places in extensive beds; it is easily fused, and affords a large percentage of good iron for castings."

Canterbury ore bed. "Two and a half miles west of the village of Canterbury, in Cornwall, is the *hematite* or *limonite* mine of Mr. Thomas Townsend. For years past this ore has been considerably used, and although a lean ore, it makes excellent iron. It is mostly in powder, or very small fragments, mixed with balls and pieces of the hematite of a few pounds weight. It lies in limestone rock, and between the limestone and the grit rock. These rocks, where connected with the ore, are decomposed to a great extent, and mixed in the state of powder with the ore; hence the ore requires washing. This stratum of limestone and hematite can be traced across this town into Monroe, until we reach the beds of magnetic oxide. It is seen a quarter of a mile north of the Clove mine, and at many places intermediate between this and the Townsend mine in Cornwall. The distance between these extreme points is full ten miles."*

This ore bed is rather an anomaly, like some of the preceding ones, in geological situation, except that, like all the limonitic hematite beds, it is connected with limestone; but *this* limestone, *unlike the others, is the Helderberg limestone, containing its characteristic fossils.* Perhaps Dr. Horton *may* be mistaken in saying that *this* limestone extends across the country to the magnetic ore beds in Monroe. If that limestone be the same, I did not recognize it with certainty, though it may be the same, modified by metamorphic action. Dr. Horton traced the rocks with much care, and the doubt above expressed has reference to the fact that the limestone of Monroe and Warwick, where their geological relations *were* traced, were found to have the position of the Calciferous group and Mohawk limestone; and the rock, when not very much altered by metamorphic agency, had the aspect, structure, texture, and composition of the limestones above described, or like the Newburgh and Barnegate limestones. The limestone at the ore bed above described lies in vertical strata, with red slate adjoining it on the east, as represented on Plate 5, fig. 13. The remainder of that section may not be altogether accurate, as the strata are much disturbed, and little examination was made, in consequence of having a great area to examine in a short time, and not being at that time aware of the important questions that might be settled by a rigid examination of this vicinity. Some of these questions in regard to the age of the red rocks of Smith's-clove valley and Green-pond mountain, and the periods of upturning of these and the Helderberg strata, have already been alluded to.

* Dr. Horton, Geological Report, 1839.

Limonites and Hematite of Dutchess and Columbia counties.

The iron ore of Columbia and Dutchess counties is very abundant, and makes iron of the best quality. The mines are numerous, and in general they are easily worked and free from water. The ore consists principally of limonite, which varies in its state of aggregation from a yellow pulverulent mass to a compact brown iron-stone. It is mammillary, botryoidal, spongiform, and with stalactitical forms, some of which have hemispherical and others acicular terminations; others are like bunches of pendant moss. The solid stalactitical forms are fibrous, with diverging radii from the centre. The specimens are beautiful, and highly ornamental as curiosities and as minerals. The mines yield an aggregate of about twenty thousand tons of ore per annum, which is worth at the bed one dollar and a half to two dollars and a half per ton. There are ten furnaces, it is said, within twelve miles of Amenia, which make, in the aggregate, about ten thousand tons of iron per annum. They afford employment to about one thousand men as ore-diggers, coal-men, teamsters, smelters, limestone diggers, etc. Some of these furnaces are in Connecticut, near the line, and it is about as well for New-York as if they were within her own limits. All the iron is carried to the Hudson river, and then shipped to various parts. There are two furnaces in Columbia and Dutchess counties not included in the above number, viz. Ancram and Hopewell furnaces. It is estimated that the aggregate annual value of the pig iron made at these twelve furnaces is four hundred thousand dollars to five hundred thousand dollars per annum. Manufactories of malleable iron in various forms are attached to some of these furnaces, as the Columbia furnace in Kent, the Ancram furnace, and some others. The malleable iron from these furnaces is highly valued for its toughness and softness, and is extensively employed in making anchors, musket and pistol barrels, wire, etc. The geological situation of the ore beds is very constant. Most of the beds that I have examined are at the junction of mica or talcose slate with the grey and white limestones. The limestone generally crops out on the west side of the ore beds, and the mica or talc slate on the east, and both dip at an angle from twenty to sixty degrees to the east-southeast.*

The ore bed at Fishkill was described by Dr. Beck, in the Geological report of 1837:

"*Fishkill ore bed.* This is the ore bed belonging to the Fishkill Iron Company. It is situated about three miles northeast of the village of Hopewell. The hill in which it occurs presents no peculiarity that I could discover, except that its surface is made up of coarse gravel, and has a rounded form in various places. The ore is covered by a stiff whitish clay, and is intermixed with the same substance, called *fuller's earth* by the miners. Quartz is also one of the accompanying minerals, and a sort of slate is often found in the centre of the masses of ore, which causes some inconvenience to the smelter. The whole bed is made up of nodules of ore of various sizes and forms, but usually rounded, which are covered, and

* The association of these rocks is not only an interesting geological fact, but it shows an adaptation of means to ends. The limestone is convenient for use as a flux, and the talc and mica slate for firestone to line the furnaces.

apparently cemented together with a yellowish brown clayey ochre. These nodules are often hollow; and when this is the case, the inner surface is highly polished, and has the appearance of having been fused. Sometimes also beautiful stalactites, of various sizes and forms, are found in these balls; and occasionally there is observed a thin lining of a black powdery matter, resembling plumbago, which is believed to be oxide of manganese. The structure of the ore is fibrous, and its color brown. This bed is worked by levels or burrows carried in various directions through the hill in which it is situated. These excavations have already extended to the distance of ninety or an hundred feet from the entrance. The roof of these burrows is from twelve to thirty feet above the floor, and is supported by pillars of ore, from five to ten feet in thickness. The ore alternates with the clay and slate, and from what I subsequently observed, I infer that the bed rests upon mica slate, although I did not find that rock in the immediate vicinity."*

Most of the galleries have caved in, in consequence of the injudicious method of working the ore. The superincumbent materials are clay, loam, gravel and pebbles, imperfectly aggregated like "hardpan;" so that when the soil becomes very wet, they have little tenacity; and as the galleries are made large, and without any support to sustain the superincumbent materials, they cave in, and render the extraction of ore, at present, expensive. The ore is of good quality, but more mixed with earthy matter than at many of the other mines.

Limestone was seen in place a few rods west of the mines, and of the same general characters as that seen at the various mines of this kind of iron ore.

"*Clove ore bed.* This is an extensive deposit of brown hematite, situated in the south western part of the town of Unionvale. The general appearance of the hill in which this occurs does not differ much from that of the Fishkill ore bed, but it appears to be more extensive, at least it has been more extensively explored. In most instances it has been worked *to the day;* large excavations having been made in various places, which communicate with some central point by means of roads or railways. The Dover Iron Company have, however, sunk a well or shaft, and are constructing a level to intersect it, a mode of working which promises to be highly advantageous. The ore is in general similar to that found at the Fishkill bed, but perhaps there is a larger proportion of the *ochrey* or *fine* ore, as it is here called, which is considered more valuable than the other varieties."*

The Clove ore bed was visited by Mr. Merrick. Messrs. Quaig and Rees have the contract for digging the ore at the Clove bed, where from five thousand to six thousand tons are dug annually. The ore is smelted in the Beekman, Dover and Bull's-bridge furnaces. The ore is delivered at the mine at one dollar and sixty-nine cents per ton, of which ninety-four cents is paid to the mine proprietors, and seventy-five cents per ton to the miners. This ore is a very pure hydrated peroxide of iron, and is mostly fibrous hematite. This bed is bounded on the east by limestone.

This ore bed is situated on the west side of a hill running parallel with the valley of the

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* Prof. L. C. Beck, First Annual Geological Report of New-York, p. 35, 36.

Clove, about one hundred feet high. The bed is bounded on the east by a ridge of limestone. A bed of white clay, or "fuller's earth" as it is called by the miners, rests upon the ore as at Fishkill. The southernmost of the ore beds at this place is worked by the Messrs. Sterling, and does not make as good iron as the others, though the ore is richer, and yields a greater proportion of iron. The ore at this place is mostly the *fibrous* hematite, similar to that of the Indian-pond ore bed in Salisbury.

Dover ore beds. The hematitic ore is found in several places in Dover. One is about a mile south of the furnace, and it supplies a part of the ore used at the Dover furnace. A small quantity was dug some years ago about two or three miles north of Hurd's corners. Prof. Merrick saw loose masses of hematite "at almost every step," in some places on the hill-side on the east flank of the Dover valley, between Hurd's corners and Dover plains. A few years ago, hematite to the amount of a few tons was dug in the southeast corner of Dover.

Prof. Beck has described the principal ore bed in Dover as follows:

"*Foss' ore bed.* Proceeding from the Clove ore bed in a northwestern (northeastern?) direction, after crossing the Chesnut ridge, we come to a deposit of ore known by the above name, in the town of Dover, about a mile and a half west-southwest from the furnace of the Dover Iron Company. This bed is situated in a valley between two spurs of the mountain which passes through this part of the country, and it is particularly interesting, as showing the association of the hematite with the mica slate, which occurs here in strata of some thickness, and contains garnets of various sizes. In extent, however, this bed appears to be inferior to those already noticed" (in Fishkill and Unionvale). "The ore is in much larger masses, and is not only more difficultly reduced to powder, but contains a larger proportion of foreign substances."*

Amenia ore bed. The Amenia and Salisbury ore beds are the most extensively wrought of any iron mines, of this kind of ore, in the United States, and the iron from these beds is considered superior in softness and toughness to that of any other mines in the country.

The Amenia ore bed yields five thousand tons of ore per annum, which gives on an average fifty per centum of pig iron. The mine is worked to the day like an open quarry. A layer of earth and gravel, and broken rocks, covers the ore from five to twenty feet in thickness. This is first removed, and the ore then excavated. They have not yet found the bottom of the ore in any place, although in one pit they have excavated into it forty-five feet. It improves in quality the farther they descend. No estimate can be formed of the amount of ore in this bed, which probably unites with the others north and south of it. Estimating its breadth at one hundred yards, and its length at one thousand yards, with fifteen yards depth, through which it is open, it is capable of yielding 1,500,000 tons of ore, and at the present rate of working will last three hundred years.

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* First Annual Geological Report, 1837, p. 36.

Talcose slate crops out a few rods east, and white limestone a few rods west of the ore bed. Mines which have been and still are extensively wrought, have been opened over a distance of more than half a mile in length; the extent of the bed in these directions is not known. Another mine, possibly a continuation of the same bed, has been opened at Squabble Hole, about two miles south-southwest of Ameniaville. The ore at this place lies under a deposit of pebbles, gravel and loam, about fifteen to twenty feet deep. It is abundant. This ore was discovered in digging a well.

The Chalk-pond ore bed was wrought extensively many years ago. It was abandoned in consequence of the water of the pond incommoding the miners. The pond has now been drained, and the mine can be worked to advantage. The ore appears well, and will undoubtedly make a good iron. This ore bed is about two and a half miles northeast of Ameniaville.

The ore bed near the village of Amenia (or Paine's corner, as it has been called,) is the one that is best exposed to examination, and from which the greatest quantities of ore have been and still continue to be taken. The position of the rocks, and the geological relations as far as known, are represented on Plate 23, fig. 2. In some places, clayey matter is intermixed with the ore. In some places it is red like the earthy red oxide of iron, yellow like iron ochre, white like pipe clay, and sometimes it is bluish. The blue clay is not plastic, but rather crumbly when wet; and it is more or less mixed with talcy and micaceous matter, and contains a multitude of minute but perfect cubic crystals of pyrites. I washed a portion of the clay, and obtained thousands of these small crystals, the largest of which were not larger than grains of sand. In the bottom of one of the openings where they were excavating the ore, Prof. Merrick found masses of crumbling impure limestone filled with minute crystals of pyrites like the clay, and he inferred that the clay came from the impurities of the limestone, and that the blue clay was the same as the limestone, only that the calcareous matter had been entirely or mostly removed; that in the white clay, the pyrites had also been decomposed, and entirely removed by the action of water or other agents; and that in the colored clays, the iron had been only partially removed.

In one of the ore beds, the solid ore was observed to be covered with a deposit of earth and fragments of ore, deposited apparently from water, and this was covered by earth mixed with gravel and rounded pebbles. Whether this iron ore forms a bed interstratified with the adjacent rocks, or a mere mass in the trough between them, is not known; whether it has been formed by the decomposition of pyrites, by the depositions from mineral water, or other causes, is not yet known.

The Amenia ore bed yields the greatest variety of the most beautiful and delicate specimens for a cabinet, of any locality of that ore that I have ever seen. Among the varieties of limonite may be mentioned the following, viz:

1. Earthy yellow ore.
2. Compact brown iron ore.
3. Glazed compact brown iron ore, like japan, in the interior of geodes.
4. Velvety ditto, from incipient crystallization.
5. Specular ditto, with a surface like burnished steel.
6. Iridescent ditto, with beautiful colors.
7. Stalactitical, in which the stalactites are elongated and pointed like a needle, extremely delicate and beautiful, from the size of a needle to one-eighth of an inch in diameter.
8. Botryoidal and mammillary forms, both of the brilliant hematite and earthy form of this mineral.
9. Ligniform or fibrous hematite.
10. Spongiform, arborescent, moss-form, columnar, reticulated, and various other undescribed imitative forms. This bed is a treat to the mineralogist.

Prof. Merrick examined one point of evidence having a bearing upon the period at which the ore was formed. He observed at the Amenia ore bed, and afterward at others, that the stalactites of the hematite hung down vertically in the cavities of the ore in the ore bed, and never found them hanging at any other angle to the horizon, except in one instance, and that he thought, from what he saw, was local, and due to a slide in the bank where it was observed. The rocks are highly inclined in the immediate vicinity of all the ore beds of this kind of ore, so far as I have observed in New-York, Connecticut, Massachusetts and Vermont. This fact would show conclusively, I think, that the stalactites found in the ore have been formed since the inclination of the contiguous rocks.*

Indian-pond ore bed. The Indian-pond ore bed lies in the edge of Connecticut, between Salisbury and Sharon, and about six miles northeast of Amenia. This bed has been described by Prof. Shepard.† It furnishes about two thousand tons of ore per annum. The limestone forms its west, and the micaceous slate its east boundary. The position of the strata is represented on Plate 23, fig. 1.

Salisbury ore beds. The Salisbury beds are five or six miles farther north. They are extensively wrought (about five thousand tons per annum). They also have been described by Prof. Shepard.‡ These ore beds are very near the line of New-York in Connecticut.

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* Prof. Beck's analysis of ore from Amenia is as follows: "A fragment of stalactites from this locality was found to have a specific gravity of 3.828; and to lose upon calcination 13.5 per centum of its weight. The composition of this specimen will probably be a fair average of that of the pure hematitic variety from the various localities in this county.

Analysis of Brown Hematite from the Amenia ore bed.

Peroxide of iron,	82.90
Silica and alumina,	3.60
Water,	13.50
Oxide of manganese,	trace.
	100.00

Proportion of metallic iron, 57·50 per cent."

† Report on the Mineralogy of Connecticut, 1837, p. 20. ‡ Ibid. pp. 17, 19.

White limestone is seen at the line or very near it. Mica slate succeeds on the east, and contains a few garnets and crystals of staurotide. The ore is apparently stratified when seen at the distance of a few rods, dipping at an angle of thirty to forty degrees to the eastward. Thin layers of clay from the decomposed rock are more or less interstratified with the ore. The valley in which Ore hill is located, seems to be a part of a broad transverse valley which crosses the range of hills at an angle about S. 65° to 70° E.

Beautiful specimens of hematite are obtained from these ore beds. The specular hematite is as brilliant as the finest burnished metal. The mammillary and botryoidal forms are very beautiful, and the fibrous and stalactitical forms are also very rich and beautiful. The stalactitical forms are different here from those at the Amenia and some other ore beds. They are hemispherical at their lower ends, and nipple-shaped and rarely acuminated. The stalactites at all the ore beds are fibrous, radiating from the centre to the circumference.

Boston-corner ore bed. "On the eastern borders of the State, near Ancram, the hematitic ore is also found; and at a place called Boston corners, *between* the State of New-York and Connecticut, is an extensive deposit of it."* I did not see the locality above mentioned. Iron ore was dug for one season in the low loam and gravel hill next the Taconic mountain, and about in the line between the Copake and Salisbury ore beds.

Copake ore bed, two miles northeast of Copake flats, is worked, but not extensively. It yields about fifteen hundred tons per annum. The limestone crops out a little west of the bed, and mica slate also not far on the east. The ore is probably abundant at a greater depth, but the mine may become a wet one if it be dug much deeper. An ore bed has also been opened two or three miles south of the above, and a mile or two north of Boston corners, in Massachusetts.

Limestone was observed a little west of the Copake ore bed, like that of the valley of the Copake, and so on to Barnegate; and a little to the east, the rock is a chloritic talco-micaceous slate, containing grains of magnetic oxide of iron. The ore bed is about a mile west of Taconic falls, at the western base of Mount Washington. The ore is compact, earthy, geodiferous, stalactitical, fibrous, mammillary, botryoidal, etc. The ore bed seems to be situated under the alluvial and quaternary deposits of the valley. The strata overlying and covering the ore consist of pebble and gravel beds, and some of the ore itself seems to have been washed and rolled.

Hillsdale ore beds. Prescott's ore bed is one and a half miles north of the Columbia turnpike, in Hillsdale. It is bounded on the west by limestone, like those of Amenia, Indian pond, Fishkill, &c. This locality was discovered many years ago, and forty tons of ore picked out of the bed of the brook, and reduced in a forge. It was not much worked until 1822, when Mr. C. Prescott began the manufacture of yellow ochre at this place. The ore

* Prof. Beck, First Annual Geological Report of New-York, 1837, p. 38.

is hematite, in detached nodules, alternating with ochre and fragments of decomposed slate rock. The hematite increases and the ochre diminishes in quantity as you descend. The ore has been penetrated, according to Mr. Prescott's statement, thirty-two feet, without finding bottom. This ore yields thirty-three per centum of bar iron when worked in the forge, and at least fifty per centum of pig iron, when smelted in the high furnace. Another ore bed is located three-quarters of a mile south of the above, also on the east side of the limestone, which was opened by Mr. Prescott in 1822, and which he has since sold to a furnace company in Salisbury, Connecticut. Mr. Prescott has made from his ore bed two hundred and seventy-five tons of yellow ochre, which has been sent to market and sold.

In Argyle, between Reed's mineral spring and South-Argyle post-office, limonite, but rather impure, was observed by the road-side; and judging from surface indications, there may be a body of it. It lies near the limestone. Similar indications were seen in many places near the broken ranges of limestone, where they are associated with the Calciferous sandstone and Potsdam sandstone, in Greenwich, Argyle, Hartford, Cambridge and Jackson; but the indications were not such as to lead me to believe there was iron ore in any great quantity, or of very good quality.

"The iron region which has just been described is undoubtedly a part of the great series of deposits which has been traced in a nearly northern direction through the States of Connecticut, Massachusetts and Vermont. Thus this ore is known to occur at Kent and Salisbury in Connecticut, at Lenox and Richmond in Massachusetts, and at Bennington, Pittsford and Monkton in Vermont. At almost all these localities it is accompanied by an ore of zinc, although in proportions too small to be detected by ordinary analysis; and in Vermont, it is associated with the oxide of manganese. At the Ancram furnace in Columbia county, where the Salisbury ore is employed, layers of oxide of zinc are formed in the chimney, and the same thing is also observed at other furnaces where this ore is used. A specimen of this substance, which I obtained at Ancram, having a yellowish color, gave upon analysis the following results in 100 parts, viz:

Carbon	1.00
Oxide of iron	2.90
Oxide of zinc	96·10
	100.00."*

The localities which have been described, are openings made in a few places, in extensive deposits of ore; and small quantities comparatively have been taken from them, while they are capable of yielding millions of tons to the enterprise of our citizens. The beds are undoubtedly continuous for great distances, and are a part of the great chain of iron deposits which extend from Canada to the Carolinas.

Although in the First geological district, we have not *mountains* of iron ore, we have beds

* Dr. BECK's Report of 1837.

which are inexhaustible, and so widely distributed as to afford facilities of water power, fuel, etc. for a greater number of furnaces than could be accommodated around one unwieldy deposit.

The origin of the beds of this ore is not known with certainty. The facts that seem common to all, are,

1. A peculiar kind of clay is associated.
2. Limestone apparently dipping under the ore, is observed in the vicinity of all of the beds.
3. All the beds are located in valleys, or on the sides of valleys.
4. They are all near rocks that are considered to be more or less modified by metamorphic action.
5. They are all on or near lines of great disturbance of the strata.

2. Lead, Copper, Zinc, Silver ores, &c.

Lead ore (galena) has been found in the impure limestone or calciferous sandstone in Whitecreek. It lies in small strings and bunches in the rock, and the indications on the surface are such as to justify the belief that it will be explored at some future time; but whether it would be a profitable investment of capital, can only be known by experiment. I would not advise any one to embark in such an enterprise, unless he could lose all embarked without inconvenience. The expenses of exploration are certain, while the result is very uncertain. It is favorably located for drainage. It has the same geological position and relations as the mine four miles south of Lebanon springs, on the east side of the road to Green river, in Columbia county; the Livingston lead mine in Ancram in the same county; and the mines on Judge Bockee's and other adjoining farms, four or five miles southeast of Pineplains in Dutchess county. The ore from the Whitecreek lead mine, like that from the other mines just mentioned, is said to contain silver. It is highly probable, but I have not assayed it.

Galena, or the sulphuret of lead, is extensively distributed in small quantities over a tract extending through Washington, Rensselaer, Columbia and Dutchess counties. In nearly every locality where I have seen it, it is situated in veins, traversing the strata near the junction of limestone with slate rocks, where they had been upturned and exposed to great derangements, and more or less affected by metamorphic agency.

Although numerous localities have been examined, none were seen where it is deemed advisable to expend much money in prosecuting mining enterprises; still, it is thought highly probable that valuable mines of this ore may be discovered.

The lead mine which has been most extensively wrought, is the Ancram or Livingston mine, in Ancram, Columbia county. Dr. Beck described the mineralogical characters of this mine in the Report of 1837. The mine was filled with water when I saw it; of course I could not examine into its minute geological features as accurately as I wished. It is situated in a talco-argillaceous and calcareous slate, a little west of its junction with a limestone, which is a perfect type of Prof. Eaton's sparry limerock. The adit, which has been partly excavated with a view to drainage, penetrates this rock for sixty feet or more. The vein,

which is of quartz, containing galena, blende, copper pyrites, etc. is about four inches wide at the surface, and widens downwards, but is very irregular in width, and branches off into bunches and strings. It is nearly vertical, and ranges S. 70° W. and N. 70° E. The strata dip eastwardly sixty to seventy degrees. The ores from this mine, when mixed, are said to yield one hundred and eighteen ounces of silver to the ton.* The mine is situated on a hill-side near a small stream called Punch brook. Many small veins of quartz, calc spar and brown spar, traverse the strata in different directions, and most of them contain small quantities of galena and blende. The principal vein has its outcrop parallel to the strike, and it passes downwards through the rocks nearly vertically, while the strata dip to the east as above stated. It seems then to be a proper vein. The geological relations of this mine are indicated, as far as is known, on Plate 23, fig. 4. The striped stratified part represents the slate, and the checkered part the sparry limestone. Dr. C. A. Lee described this mine in 1825.†

Prof. Beck thus describes this locality:

"At this mine two or three veins of galena may be observed on the surface, which with their gangue vary in width from a foot to three or four feet. When they widen, as they sometimes do, the ore is very sparingly disseminated in the calcareous spar and quartz, which constitute its principal associates.

"The occurrence of the lead ore at this locality, reminded me of that of the copper ore at Flemington, New-Jersey. It does not appear to constitute a true vein, but to be a collection of strings communicating with beds of various dimensions. These strings are parallel with the strata, and not at right angles to them; and in no case did I observe the ore separating from the walls, as it often does at the Rossie vein, but it gradually loses itself in the accompanying rock.

"The mine seems at present to be judiciously worked, although I have reason to believe that it has not answered the expectations of the proprietors. The principal shaft is about seventy feet in depth, and from this runs a shore level which communicates with another shaft, opened many years since, and which now performs the part of a ventilator. At the base of the hill, a level has been commenced, which is intended to cross the deposit of ore, and will, when completed, be about one hundred and fifty *feet* (yards?) in length.

"The galena is both crystalline and granular. It is associated with quartz, and occasionally has mixed with it some carbonate of lime. But the former constitutes the principal gangue, and the difficulty of separating it from the ore renders the processes necessary for its reduction comparatively tedious and expensive.

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* Cleaveland's Mineralogy, p. 633.

† American Journal of Science, Vol. 8, p. 24.

Analysis of Galena from the Ancram lead mine.

No. 1.		No. 2.	
Sulphur	13.00	Sulphur	12.68
Iron	83.65	Lead	81.61
Silica	3.50	Silica, &c.	5.71
Carbonate of lime	a trace.		100.00
	100.15		

"In some of the specimens of galena, I observed small plates of a yellowish color, which may be the molybdate of lead, said to occur at this locality; but I did not find it in sufficient quantity to make it the subject of experiment. Two varieties of sulphuret of zinc are associated with the galena, both of them having a brown color. The one is foliated, the other compact.

Analysis of Sulphuret of Zinc from the Ancram lead mine.

No. 1, Compact.		No. 2, Foliated.	
Sulphur	33.56	Sulphur	33.20
Iron	4.30	Iron	6·45
Zinc	61.64	Zinc	57.85
Silica	0.50	Silica	2.50
	100.00		100.00

"Pyritous copper of a golden yellow color is also occasionally met with at this locality."*

The next most important localities noticed were in Northeast, about five miles southeast of Pineplains, on the farms of Judge Bockee and Mr. Ward Bryan. Many openings have been made on these farms, and lead in some quantity has been procured from them. These mines were worked about 1740, by a company of Germans, and the ore was sent to Bristol in England, and Amsterdam in Holland. The ore is said to yield forty-five ounces of silver to the ton, and the copper ore eighty ounces to the ton. It was not profitable, and was abandoned. During the Revolution they were reöpened by Peter M'Daniels, under the direction of the Committee of Safety of Congress, with a view to supply the army with lead. Some tons of it were procured, but as the mines were abandoned, it is presumed they were not productive. The veins cross the strata in a direction nearly west and east. At one of the openings, about half a mile southwest of Judge Bockee's, on Mr. Ward Bryan's farm, a little north of the road, in the second or third pit, we took out forty or fifty pounds in an hour, from a vein about an inch wide. This ore is very pure, and will yield about eighty to eighty-five per centum of lead, and it is said to contain some silver. The vein is too narrow to warrant mining, unless one depends upon the doctrine of chances. Blende occurs in the same vein, in several

* First Geological Report of New-York, 1837, pp. 56, 57.

places. In the next pit north, next the wall (stone fence), a vein an inch thick of galena and vitreous copper ore was seen.

Many small veins were seen in the limestone north of this opening, in the bed of the brook, and which contained particles and masses of several ounces, and even pounds weight of pure galena.

The excavations on Judge Bockee's land, which extend south from those above mentioned, and continue at short intervals for half a mile, show numerous small veins of galena, all of which contain black sulphuret of copper, with some yellow copper ore (pyritous copper) and green and blue carbonates of copper. All the openings are in the limestone, (which is of a bluish grey, nearly compact,) and a few rods east of its junction with the slate on the west. The great number of small veins in this vicinity renders it highly probable that larger ones occur, of which these are mere strings. The best veins seen were in the most southerly openings. Veins permeate the whole rock in an east and west direction, and contain quartz, galena, blende and vitreous copper ore, with some pyritous copper and carbonate of copper. The geological relations, as far as observed, are represented on Plate 23, fig. 5 ; H represents the slate, and L the limestone.

The lead veins, called also silver mines of Canaan, have attracted some attention. They are located near Whiting's pond, perhaps one or two miles south, and not far from the "Yellow meeting-house." One of them lies on the east side of the road on the hill, in limestone ; and the other appears to be in quartz veins, which traverse the strata. It could not be examined without some difficulty, as the shaft was filled with brush. Fragments of quartz and ore were scattered at the mouth of the mine. The ore is a mixture of fine-grained galena and yellow blende. Fragments of several inches in diameter were obtained, showing that the vein was several inches wide in some parts. The ore is said to be rich in silver, and to have been worked half a century ago by some Germans as a silver mine. The rock is the grey and whitish sandy limestone of the New-Lebanon and Canaan valley. One said the shaft was ninety feet deep ; another that it was thirty, and had a gallery thirty feet long at its bottom.

Numerous small veins of galena are reported to occur in the vicinity ; and Mr. Calvin Prescott, of Hillsdale, informed me that he had seen galena in many places in the limestone ledges on the farm of Capt. Burr, on the east side of the road near the same place, near the Hudson and Albany railroad, and a few rods south of the silver mine, so called, on the land of Calvin Pease. Black and yellow copper ores (sulphuret of copper and pyritous copper) occur in small quantities, associated with the galena.

Near the localities mentioned above, is a reputed silver mine. It has been opened within a year or two. It is leased by Elder Ford and Mr. Holmes. Elder Ford showed me three hundred or four hundred pounds of the ore. It is disseminated through quartz, and unless it be very rich in silver, would not pay the expense of picking, stamping, washing and smelting. I examined the mine, and found small quartz veins traversing the limestone in an east and west direction. A single particle only of the galena was observed, which would not weigh more than forty grains. There are no indications, to my mind, that would justify a

mining enterprise. Superstition, as in many other instances which have come under my observation, has been busy. This mine is stated to have been discovered in a dream, by an apparition pointing out this as the locality of a rich silver and lead mine, to a Mr. Holmes, the father of one of the lessees, about thirty or forty years ago. He sold the farm many years since, went to the west, and after an absence of more than twenty years, returned, took a lease of the lot, and opened the place where he had dreamed a rich lead and silver mine had been indicated to him. He gave one half his interest in the mine to his son, and sold the other half. It was worked some in 1837.

Mr. Calvin Prescott of Hillsdale, who has long been a close observer of the minerals of that region, imparted to me the following localities where small quantities of galena have been found. Several of them were examined by Prof. Cassels and Mr. Merrick, in company with Mr. P., but there are no indications supposed to be worth pursuing for *mining* purposes.

Fine grained galena is found in Dover, in a small vein in dolomite, near John Preston's inn. Galena has been found in Hillsdale, on land of Uriah Sornberger, Andrew Shortis, David Collins, Richard A. Wheeler, Sylvester Williams, and John F. Collins. These are all situated in quartz veins which traverse the limestone, and the ore is disseminated in small grains and bunches.

On the road from New-Lebanon to Stephentown, a lead mine is said to exist; but Prof. Briggs, who examined the locality, could trace no appearance of lead ore.

Lead ore is said to occur in Amenia,* but I could learn nothing in relation to it from the inhabitants. A vein of galena is also said to have been found in Claverack,† and at Rhinebeck.‡ Another was reported to occur in Ghent, where lumps of the size of a person's head were easily obtained, but I could not ascertain its exact locality. Mr. Staats, of Hudson, informed me of another locality in Ghent, on the farm of Martin Harder.

A small string of galena is stated to have been found in digging a vault on the east side of Indian pond, in limestone. The vein traversed the rock from east to west.

In Stanford, lead ore is said to occur on the land of Asa Thorne, and also on that of Asa Thompson.

Copper ore in small quantity was observed on Gen. Brush's farm, in Amenia. This locality was worked for copper ore some twenty years ago. It is about one hundred rods west of the City meeting-house.

Copper ore, principally of the black sulphuret, has been mentioned in Judge Bockee's lead veins, in Northeast. It also occurs in New-Canaan, Columbia county, on land of Daniel Pease. Mr. Prescott, who mentioned this locality to me, states that it contains copper, lead, and silver. Mr. P. also observed a small vein of pyritous copper on the farm of John F. Catlin of Austerlitz, in veins of white quartz, traversing limestone; also on the mountain east of Green river, about a quarter of a mile from the inn formerly kept by Hatch. Mr. Prescott says this is the blue copper ore, in a narrow vein; and that a similar one occurs in

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* Cleaveland's Mineralogy, p. 633; and Robinson's Catalogue of Minerals. † Ibid. ‡ Ibid.

Hillsdale, on the farm formerly owned by Mr. Jesse Squire. Copper pyrites occur rather abundantly in the Ancram lead mine, but not enough to be worth separating.

Copper pyrites was observed in the siliceous slate, on the road from Lower Redhook to Upper Redhook landing, but in small quantity. It is on Nathan Beckwith's land.

Galena has been found in several localities in New-Lebanon. Lead ore occurs in an old mine in Livingston, on the farm of John E. H. Plass. Pyrites and blende are also associated.

Another mine hole is seen about one hundred and fifty to two hundred yards southeast of the one just mentioned. The hill in which they are contained is called the Red hill, in consequence of the deep red color of the soil. The ore is contained in a stratum of rock resembling compact trap. It is about two or three feet thick, and dips thirty to forty degrees to the eastward, parallel to the slate.

In Fishkill, on Mr. Van Wyck's farm, one mile southeast of Johnsville, Mr. Merrick saw a thin vein of quartz in limestone, which contained galena and some copper pyrites.

Blende occurs abundantly with the lead ore at the Ancram lead mine. It is both yellow and crystalline, brown and compact. It was also seen in veins one quarter to one inch wide, in the limestone at Mr. Ward Bryan's and Judge Bockee's lead mines in Northeast. It was seen in small quantities at most of the lead diggings in various parts of Columbia and Dutchess counties, but more abundant and beautiful at the old "Silver mines," in Canaan, two miles south of Whiting pond.

In Northeast, on Mr. Lee's farm, about four miles north of Amenia, are excavations made some years since in search of silver. They are in quartz veins in the talcy slate rock, near the junction of this rock and the limestone. Pyrites occur in some abundance there, but no other ore was seen.

In the northeast part of Lagrange are numerous excavations, said to have been silver mines, from which, according to tradition, large quantities were obtained in olden times. Mr. Merrick could discover no traces of any metal except a few particles of pyrites, and the money made there was probably "out of pocket."

Silver mines have often been mentioned to me as occurring in particular localities, but investigation showed, in at least nine cases in ten, that pyrites was the deceptive mineral. A silver mine is reported to exist in Hillsdale, on Barney Overhizer's farm. It is probably pyrites.

Too many are still believers in the mineral rod, and suffer themselves to be duped by the designing; but there are some who *use* the mineral rod, and are *ignorant of the cause of its motion*, who firmly believe in its virtues. It is time that this faith in the mineral rod should be exploded, and that all should understand that those who profess to be able to find minerals, ores, etc., by a witch hazle, peach, or any other forked twigs, or strips of whalebone with a silver or other knob on the end, are either *knaves* or the dupes of their own ignorance.

In the Shawangunk grits, metalliferous veins have been found in several localities, about the Shawangunk mountains, as stated on page 358 of this volume; and to the account there given of the Ellenville mine, it may be proper to add, in reference to the direction of the

metalliferous veins at that place, that the probability is that the most productive part of the vein would be in the limestone of the valley, and which probably lies a little west of the base of the mountain and of the adit level. Prof. Beck supposes, from the observations made, that the direction of the vein was entirely mistaken.* He does not mention the direction in which he supposes it to run, but it may be inferred that he thinks it runs parallel with the strike of the rocks, like that of Wurtsborough and Red-bridge, and it is probable that this may be the direction of the main vein.

In concluding my description of the Ulster mine near Redbridge, (page 359 of this volume,) which has been worked by the North American Coal and Mining Company, I stated an intimation that the company had determined to expend the sum of ten thousand dollars in making explorations during the year 1839, and at the same time expressed that my own intention had been to reëxamine this mine. I have not been able to make such reëxamination, and therefore can form no definite opinion as to the results of the company's operations; but Prof. Beck examined it the next year (1840), and says, "The work has not recently been prosecuted to any extent; but I know of no peculiarity in the character of this mine, and there can be no reasonable doubt that a large amount of ore is here to be found. It may also be observed, that its metallic minerals are similar to those found in the Sullivan mine, and that they are associated with groups of quartz crystals, which are often of great beauty."†

I examined this mine soon after the first shaft was commenced in 1837, and fig. 1 of Plate 39 shows the geological relations as far as they were observed. (*a*) represents the vein of quartz containing the metalliferous minerals, parallel to the strike, but not parallel to the stratification; (*b*), slate like argillite, with layers of pyritous quartz between. The layers of the argillite were arched and broken, and confused between the sides of the fault or fracture of the adjacent grit rocks of the Shawangunk grit. The dip of the rocks in this vicinity varies from twenty to sixty degrees to the west-northwest, and the strike is in the direction of the mountain.

I have given (pages 359, 360 and 361 of this volume) a full description of the Shawangunk or Sullivan mine, located on the Shawangunk mountain near Wurtsboro' in Sullivan county. Prof. Beck, speaking of the relative amount of the lead ore and of the vein stone in this mine, says, "the average quantity of ore in a cubic yard of the vein is as great, if not greater than that of any lead mine now known in the northern part of the State. The Sullivan and St. Lawrence mines may be thus briefly contrasted: In the latter, there are very small veins of good ore, with very good associates, very easily reduced; but the situation of the mines is bad. In the former, there are large veins, with bad associates, more diffioult of separation and reduction; but the mines are admirably situated, whether we regard the removal of the ore, or the facility of transporting the produce of it. And perhaps, in one word, the Shawangunk lead mines (so called) have been somewhat underrated, while those of Rossie have been much overrated."‡

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* Fifth Annual Geological Report, 1841, p. 7. † Ibid. p. 7. ‡ Ibid. p. 8.

The lead ore of this mine contains a small quantity of silver. I believe I was the first to detect it, in the winter of 1837. I did not ascertain the proportion of silver, but think it probable that it may be worth separating by the improved methods of concentrating the silver in smaller portions of the lead, and thus increasing the richness in a small proportion of the lead obtained from the ore.* Prof. Beck repeated my process of cupellation, and also obtained silver.

As this method of cupellation is very easy to be performed by any person who can use a blowpipe, is very neat, and can be effected in a few minutes, it is detailed below. It can be performed at any time by apparatus that will not necessarily occupy more space in a person's pocket than a pocket knife, and saves the expense and trouble of a cupelling furnace, muffles, etc., which must necessarily be fixtures, and not easily portable.

If the ore to be examined for silver or gold, be a lead ore, it is to be reduced to the metallic state by the ordinary methods. A small piece of the lead, of the size of a duck shot or larger, is to be placed on a thin slip of mica, and then melted by the blowpipe flame of a candle or lamp. As the heat increases above the melting temperature of the lead, the globule will become perfectly brilliant; and finally a peculiar flickering, brilliant surface will show itself, caused by the oxidation of the metal and the fusion of the oxide of lead. The oxide of lead melts at the temperature at which this appearance is developed, and spreads itself on the mica. It soon ceases to *spread*, and collects around the globule of melted lead, which is continually diminishing in magnitude, in consequence of the oxidation of the metal in the oxidizing blowpipe flame. When the globule of melted lead is nearly buried in the mass of the surrounding oxide, the slip of mica should be permitted to cool. The globule of lead should then be removed by forceps, or other means, to another place on the slip of mica, where the same oxidizing process is to be repeated successively. Finally, when the globule shall have been reduced to the size of a small grain of sand, it should be placed on a fresh, clean slip of mica, and again heated in the same manner. If the lead contains the least trace of silver, it is easily made manifest in this way, because, the silver, when once free of lead, (which continues to oxidize to the last,) remains unchanged, as a brilliant white globule, which can be frequently seen distinctly with the naked eye, and when too small for this, by examination with the magnifier. If the oxidation of one globule of the lead does not give decisive indications of silver, a satisfactory conclusion as to the lead being argentiferous or not, may be obtained by oxidizing five to ten such globules down to a very small size, and then uniting these by fusion on a slip of mica, and continuing the oxidation to its ultimate limit. A person accustomed to blowpipe manipulation can determine in a few minutes if silver be present in any lead which may be suspected to contain it. With the table blowpipe,

* "A detailed account of this process, with various statements, intended to show its importance to Great Britain, is contained in the abstract of the proceedings of the last meeting of the British Association for the Advancement of Science, published in the London Atheneum. It has been republished in the Family Magazine, and perhaps in other American periodicals." (Third Annual Geological Report of New-York, 1839, p. 51.)

or the hydrostatic blowpipe, an ounce of lead may be cupelled in a very short time, and the relative quantity of silver determined, if it be appreciable.

If the ore to be examined be not an ore of lead, some of the ore is to be melted in a clean crucible which has never been used, and lead free of silver and gold added, and stirred and mixed with the fused ore. The fusion of the ore should be so perfect as to permit the lead to settle to the bottom of the melted ore. The lead, in consequence of its affinity for the precious metals, unites with them if present, and forms an alloy. The lead, cupelled as above, will show the silver or gold, or an alloy of them, if either or both of them were present.

If the globule obtained by the cupelling operation be suspected to be an alloy of silver and gold, it is examined in the usual way, and the metals separated qualitatively, or quantitatively, as circumstances may require.

Several mines have been opened in Putnam and Westchester counties, under the expectation of obtaining silver. I have examined a great number of ancient diggings in Putnam, Orange and Westchester counties, where it is reported or imagined that silver has been, or is to be found; but I have seen no indications worth pursuing, or any ore that is known with certainty to contain silver. These ores have not been analyzed, and it is not known that they even contain any silver, except from the common reports of the country that silver has been obtained from them.

Almost all the diggings are in or contiguous to limestone. Many interesting mineral localities have been opened, and an abundance of crystallized minerals dug out, and prepared for the hand of the collector of these beautiful productions of nature.

It is, perhaps, superfluous to go into a detail of the numerous mining explorations in search of the precious metals in the Highlands; suffice it to say, that superstition and the mineral rod have been freely employed, and credulous persons have permitted themselves to be imposed on, and in some instances have expended their all, in explorations which any one versed in minerals, and acquainted with their associations, would have known from the beginning were hopelessly fruitless. Common pyrites and magnetic pyrites were repeatedly brought to me while I was stationed at the United States Military Academy, as an instructer of chemistry, mineralogy and geology, as specimens of gold ore, silver ore and tin ore, by the mine hunters, or by those who had been imposed on. After examining mineral localities where lead and tin ores had been said to have been discovered, I have seen none in place, and have reason to believe that the specimens shown to me, did not originate where they were said to have been found. A piece of metallic antimony was shown to me, and was said to have been found in Putnam county; but it had the peculiar foliated crystalline texture that is generally seen in that which has been melted, and which is different in aspect from the native antimony.

While on this subject, I will notice another fact that came under my observation. Coal was said to have been discovered in the primitive region of Putnam county. I was shown a lump of beautiful *Mauch-Chunk anthracite!!* which had been buried by some means unknown

and dug up,* and this was the evidence of the reported coal mine. It is hoped that our citizens will no longer suffer themselves to be duped by designing persons into mining speculations, most of which have a baseless foundation.

"The copper, silver and lead mine" of Singsing, is on the State farm, and has already been described, as well as the copper mine at Sparta. Copper ore also forms a small vein in the marble quarries at the Prison. It occurs also in small quantities in the cliffs near the shore, about one hundred yards southeast of the brick-kiln at Sparta. It has also been found in small quantities in several places in the township of Mount-Pleasant, farther from the river. As it occurs in so many places in this vicinity in small strings and nests, it is not improbable that workable quantities of the ore may exist there, but I would advise persons to be cautious in investing capital for mining explorations. The working of metalliferous veins, with the exception of iron, has thus far in this country been like a lottery, whether for gold, silver, lead or copper. There are some that have proved to be good investments, and have yielded permanent profits; but, on an average, at least nine-tenths of them have cost far more than they have produced. Should the State lack employment for the convicts at Singsing, it might be worth while to make some investigations of some of these veins.

Copper ore has been found in several places in Putnam and Westchester counties, but not in such quantities as to justify exploration. Pyritous copper and green carbonate of copper are found in small quantities in the gneiss rocks at Phillips's mills, one mile and a quarter east of West-Point; also at Phillips's iron mine, eight miles northeast of Coldspring landing.

Arsenical iron occurs in several places in Putnam county; but the only locality known in that county to which any practical importance is attached, is about four or five miles northwest from Putnam court-house, and about half a mile southwest of Pine pond, in the township of Kent, near the serpentine marble quarry. This is one of the old mine holes from which silver is reported to have been obtained. The mine is now owned or leased by a mining company, called the Hudson River Mining Company. It had been cleaned out when I saw it. The shaft is forty feet deep. Yellow pulverulent sulphuret of arsenic covered the sides of the shaft and the timbers, wherever they had been covered by water, resulting from the decomposition of the arsenical sulphuret of iron. This latter mineral abounds there. It forms a bed or mass in hornblendic gneiss rock above the shaft, and is there undergoing decomposition, forming arseniate of iron. The ore does not, so far as I could perceive, form a vein, but is a mass; and from the surface indications, and from what I saw in the mine, there is a probability of the existence of a great quantity of this ore. The mine goes by the name of the *silver mine*, and it is stated that silver has been obtained from it; but the individual who is said to have analyzed it, has no public name as a chemist; and until it shall be analyzed by a disinterested person of reputation as an analytical chemist, confidence ought not to be reposed in the statement that it is a silver ore. This kind of ore is wrought as a silver ore in Germany, where it contains some of the precious metal. It is possible *this* may *also* contain

* This was afterwards ascertained to have been buried by a designing person, with a view to get up an excitement, and organize a company to dig there for coal.

it, and even should it *be* argentiferous, it may not contain enough silver to make it worth separating. The ore contains much arsenic, and it may perhaps be profitably wrought to furnish the common white arsenic of the shops. It is well known that large quantities of this material are consumed for various purposes in this country, such as the manufacture of shot, flint glass, medicinal preparations, etc., and the supply is at present derived from Germany. This mine would probably supply the demands of commerce.

This ore of arsenic has also been found in two localities in Warwick; one in a vein not far from Mount Adam, between that and Edenville; the other is thus described by Prof. Beck:

"There is a locality of arsenical minerals on the lands of Mr. B. Hopkins, near the village of Edenville in Orange county, which is particularly deserving of notice. I visited it in company with Dr. Horton during the last summer, and with some difficulty we succeeded in obtaining specimens of considerable interest to the mineralogist. These are, arsenical pyrites of a silver white color, occurring in a vein in the white limestone, and which I found to be composed of arsenic, sulphur and iron. Associated with this is the arseniate of iron, or cube ore, as it is called, from the primary form of its crystal, which here occurs as a coating, and possesses a beautiful green color and an adamantine lustre. Every where investing the two preceding minerals is a powder of a lemon-yellow color, which is ascertained to be the sulphuret of arsenic or native orpiment. In another part of the same vein is found a considerable quantity of the red oxide of iron, which, together with the sulphuret of arsenic, has undoubtedly been produced by the decomposition of the arsenical pyrites. And in addition to these metallic minerals, we have also arragonite in delicately radiated fibres and of a snow white color, and occasionally thin laminæ of transparent sulphate of lime or selenite. On the whole, this is one of our most interesting localities, not only on account of the minerals which it affords, but of the apt illustration which it presents of the changes produced in the mineral kingdom through the influence of chemical agencies." This vein is connected with the white limestone of Warwick.

An ore of *titanium* (crichtonite) has been found in Warwick, and variable proportions of titanic acid are also contained in several of the magnetic iron ores of Putnam and Orange counties.

Titanium ore has been found in several places in Putnam county. At almost every locality where augite and scapolite are found, (and the localities are numerous,) sphene or the silico-calcareous oxide of titanium is also found associated. Sphene, beautifully crystallized, was discovered by Dr. Barratt at Coldspring landing, in 1822, during the excavations for the foundation of the long block of buildings next the shore on the north side of the village. Specimens were obtained at that place in abundance by Dr. Barratt, and more beautiful than any that I have seen from any other part of the country. Titanium has, however, been applied to but one useful purpose, and that of comparatively trifling importance, viz. for tinging the enamel of artificial teeth of a slight yellowish color, like the natural teeth. It has also been found in a great number of localities in Orange county. Wherever observed, it is associated with augite, scapolite, and limestone. It seems almost confined in the First district to those rocks we have described as metamorphic.

An ore of *cerium*, called allanite, occurs in several localities in Phillipstown and Cornwall, within two miles of Fort Montgomery, and it is thought other ores of this metal were observed some years ago. One of them was partially examined, and reägents showed some of the traits of that metal.

IV. CRYSTALLOGRAHPICAL EXAMINATION OF SOME MINERALS.

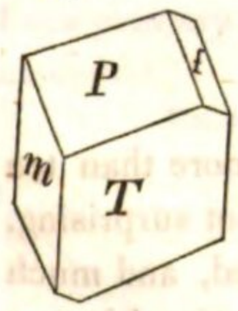
1. CRYSTALLIZED SERPENTINE.

Serpentine was found crystallized at Hustis's quarry in Phillipstown, Putnam county, first by Dr. Barratt in 1821, and secondly by Cadet Ward, November 5th, 1831. As by means of crystals from this locality I have been enabled to ascertain the primary form and its elements, I will state the facts and investigations as they occurred, from my diary.

November 5, 1831. On an excursion to-day, with the first section of my class in mineralogy, to Hustis's quarry, Cadet Ward handed me a specimen of serpentine for examination. I immediately observed traces of crystallization, there being numerous well characterized laminæ, and showing tolerably brilliant cleavage planes also in other directions.

November 7, 1831. I have succeeded to-day in determining imperfectly the angles of the primary form, but the faces are not sufficiently brilliant to give a perfect reflected image with the reflective goniometer. The measurements seem to indicate a doubly oblique prism, and there is a distinct cleavage also parallel to the shorter diagonals of the faces T and T′.

Fig. 26.



P on *m* ...	99°26′
P on *m*′ ...	80 34
P on T ...	95 20
P on T′ ...	84 40
m on T ...	92 00
m on T′ ...	88 00
P on *f* ...	128 00 to 128°30′

From these measurements, it appears to be a doubly oblique prism of

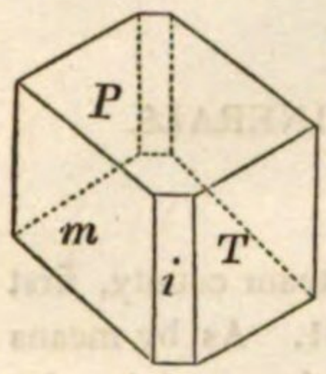
P on *m* ...	99°26′
P on T ...	95 20
m on T ...	92 00

The ratios of the edges cannot be determined, until crystals having planes modifying the primary edges shall be found and measured. Much of the serpentine in some parts of the hill-side at Hustis's quarry is granular, and some is laminated. Cadet Bailey, now Professor Bailey at West-Point, and who was one of the section of the mineralogical class, also presented me with a specimen of crystallized serpentine imbedded in carbonate of lime. There were several hexagonal crystals terminated, one of which was nearly perfect. The crystals and crystalline masses are more perfect than any I have seen from the Easton locality, and Dr. Swift was so kind as to send me some of the best specimens of that locality.

The crystallized serpentine also occurs at Warwick in the white limestone (Vide *American Journal of Science*, Vol. 9, p. 212). Professor Nuttall makes the angles 96° and 84° (Vide *Robinson's Catalogue of American Minerals*, p. 296).

October 11, 1834. Another crystal of serpentine, obtained from Hustis's quarry, measured with the reflective goniometer, gave the following angles. The planes were tolerably brilliant, but did not give a *perfect* reflection. The whole of the measurements are given.

Fig. 27.

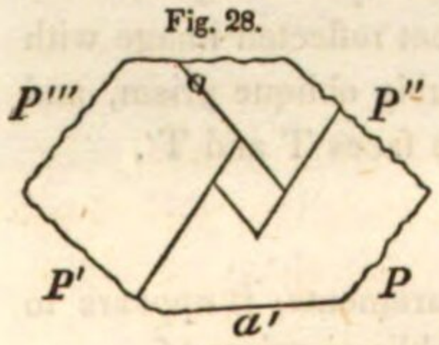


					MEAN.
m on T,	93°04′;	93°00′;	92°58′.		93°00′ 40″
m on *i*,	136 40;	136 50;	136 50;	136°40′; 137°00′.	136 48 00
T on *i*,	135 50;	135 40;	136 09;	136 04; 136 05.	135 59 36

These mean angles exhibit a small error, the sum of *m* on T and the supplements = 180°12′ 4″ = to 12′ 4″ excess. Correcting for this excess, the angles would be about *m* on T, 93°00′
m on *i*, 136 54
T on *i*, 136 06

Dr. Barratt found a large weathered crystal of serpentine at Hustis's quarry in 1821 or 1822. His measurements of this rough crystal, with the common goniometer, are 115° 15′ and 64° 45′; and Professor Shepard's measurements of the same crystal, 115° and 64°; and others as follows :

Fig. 28.



P	on P″, or P′ on P‴,	115°	to 116°
P″	on *a*	140	
P‴	on *a*	110	
P′	on *a*′	140	
P	on *a*	110	to 111

Prof. Shepard's and Dr. Barratt's measurements of the same crystal differ more than ten degrees in one of the angles, and more than five degrees in another; but this is not surprising, in consequence of the great irregularity of the faces, having been long weathered, and much worn and rounded. These measurements, of course, are too imperfect to be admitted in any investigations concerning the primary form. Prof. Shepard classes serpentine as a right rectangular prism (*Treatise on Mineralogy*, p. 168). The measurements that have been given, which were made with the reflective goniometer, may be depended on within a few minutes of a degree, and they indicate a doubly oblique prism, of which the following angles are elements, viz : P on *m* = A = 99°26′
P on T = B = 95 20
m on T = C = 93 00

From these angles, we can calculate the plane angles of P, *m* and T, by the formulæ of spherical trigonometry :

$$\sin \tfrac{1}{2} a = \sqrt{\frac{-\cos \tfrac{1}{2}(A+B+C)\cos \tfrac{1}{2}(B+C-A)}{\sin B \,.\, \sin C}};$$

$$\sin b = \frac{\sin a \,.\, \sin C}{\sin A}; \qquad \sin c = \frac{\sin a \,.\, \sin C}{\sin A}.$$

The plane angles *a*, *b*, *c*, deduced from these formulæ, are,

For the face P = 92°59′ and 87°01′
.. .. .. *m* = 93 14 and 86 46
.. .. .. T = 98 26 and 81 34

The plane angles of a right section of the defect (*i*), are as follows :

T on *i* (the supplement) = 43°54′
m on *i* .. .. = 43 06
T on *m* .. .. = 93 00

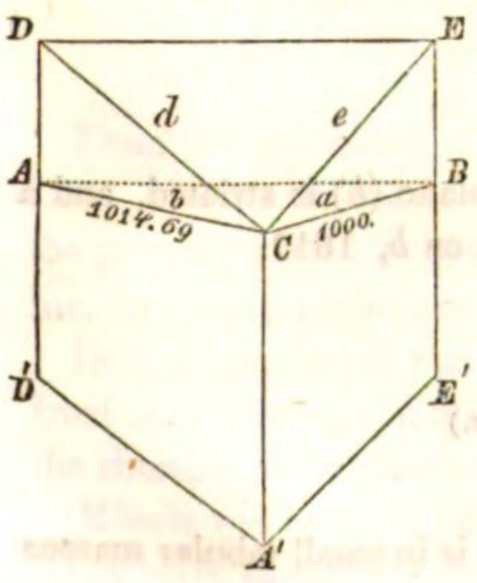
The ratio of the three edges of the right section of the defect, are,

$$a : b : c :: 1000 : 1014{\cdot}69 : 1462{\cdot}5;$$

for, $b = \frac{a \,.\, \sin B}{\sin A}$, and $c = \frac{a \,.\, \sin C}{\sin A}$; whence, *a* being = 1000,
b is = 1014·69,
and *c* is = 1462·50.

The ratio of the edges of the right section of the defect, the plane angles, and the inclination of the primary planes being known, the ratio of the edges of the defect on the plane P is easily calculated.

Fig. 29.



The triangles DCA and ECB are rightangled, on account of the parallelism of the primary edges CA′, DD′, EE′, and the section ACB of the defect being a right section.

DCA = DCA′−ACA′ = 93°14′−90°= 3°14′
ECB = ECA′−BCA′ = 98 26 −90 = 8 26

In the triangle DCA, $DC = \frac{R \times CA}{\cos DCA} = 1015{\cdot}57$

In the triangle ECB, $EC = \frac{R \times CB}{\cos ECB} = 1010{\cdot}93$

In the triangle CDE, two sides and the included angle are now known. To determine DE, we have the formula

$$\text{tang } \tfrac{1}{2}(D-E) = \frac{\text{tang } \frac{1}{2}(D+E)\,(e-d)}{(e+d)}; \qquad \text{and ED} = \frac{EC \,.\, \sin C}{\sin D} = 1470.$$

The ratios of the three edges of the defect on the primary plane P, are,

$$CD : CE : DE :: 1015{\cdot}57 : 1010{\cdot}93 : 1470{\cdot}00.$$

The ratios of the two edges CD and CE are so nearly equal, that we may infer the law of decrement on the edge CA′ to be one row of molecules; and that the line DE is parallel to the diagonal of P, and consequently the edges of the primary form, on the plane P, bear the same ratio as the lines DC and EC, viz. 1015·57 : 1010·93. The angles of the plane (*f*) are too uncertain to attempt the determination of the law of decrement on that edge, and the ratio of the remaining edge of the primary form. This is still a desideratum.

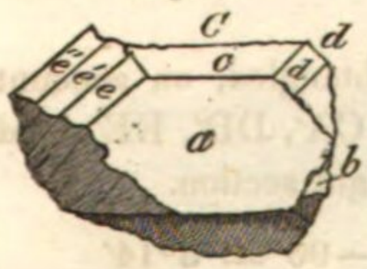
2. HIGHLANDITE. ALLANITE? (Supposed to be.)

It has not been analyzed, unless Prof. Beck has procured specimens and analyzed it.

This mineral occurs at the white augite and coccolite locality near Mr. Potter's, about one mile northwest of Fort Montgomery. It also occurs on the east side of the Hudson, on the neck of land on which the "old silver mine" is located, about five miles south of West-Point.

Characters. It is black, and dark-bottle green; lustre resinous on the fracture, but on the surface of crystals it is strongly shining, almost splendent, and semi-metallic. It does not yield to the knife, and scratches glass. It has much the aspect of dark colored crystals of the oxide of tin, but its specific gravity does not exceed 4. It is fusible with much intumescence into a greyish slag on charcoal, and does not become magnetic. With borax it fuses and gives a slightly colored yellow globule, with an undissolved skeleton within. I have often observed this mineral in connection with the limestone and augite rocks, between West-Point and the Dunderberg mountain, on both sides of the Hudson.

Fig. 30.



The following angles were measured with the reflective goniometer. The planes were brilliant, and gave good reflections, except the small plane (*b*).

a on *c*,	129°04′
a on *d*,	128 10
a on *e*,	150 00
a on *e′*,	119 42

a on *b*, 159 00. This plane (*b*) is striated, and a good reflection was not obtained. The common goniometer gave *a* on *b*, 161°.

These measurements were made in June, 1833.

3. RED TABULAR MINERAL. (Probably new.)

This was sent to me by Dr. Young, in October, 1832.

It is found in the white limestone near Amity, Orange county. It is in small tabular masses

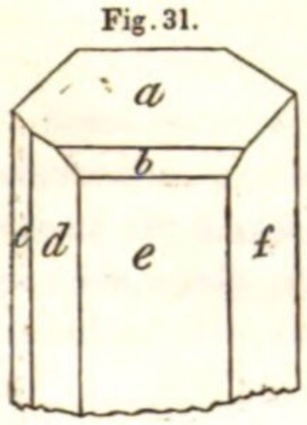
about $\frac{1}{10}$ inch in diameter and $\frac{1}{50}$ thick, with brilliant pearly and adamantine lustre on the faces of the tables; no other brilliant planes could be perceived. It is hard; scratches quartz, but does not topaz or spinelle. It is transparent to translucent, and sometimes nearly opake. When transparent, it is of a light rose-red; when translucent, reddish grey. Cleavable in one direction (that of the planes of the tables). Cross fracture uneven and splintery, with a shining lustre.

It is infusible either *per se*, with borax, carbonate of soda, or with microcosmic salt. With microcosmic salt the glass became yellowish when hot, after having been long heated, but was colorless when cold, and the particle of mineral did not appear to have been diminished in size, or to have dissolved in any perceptible degree in the flux.

4. YOUNGITE, (so called,) of Amity. SCAPOLITE?

Crystals sent me in 1832. It occurs crystallized and massive, in the white limestone of Amity, New-York. It scratches glass, though impressible with a knife. Color is grey and brownish grey, occasionally with a scarcely perceptible tinge of red. Before the blowpipe, on a platinum support, at a high heat, fuses with some intumescence, and an intense glow like lime, into a translucent white or grey globule. Borax being added, does not dissolve all, a skeleton remaining, and the highest heat that could be raised produced no additional effect. It has many of the characters of scapolite. The crystals were not brilliant, but the planes were smooth. The following measurements were made with the common goniometer:

Fig. 31.



a on *b* ..	147°00′
b on *e* ..	106 10
c on *d* ..	149 00
c on *e* ..	90 00
d on *e* ..	123 00
d on *f* ..	116 30

The cleavage planes are parallel to *d* and *d′*. Some of the angles correspond nearly with augite and scapolite.

5. PARGASITE, BLENDE and RUTILE, of Amity.

From the specimens of pargasite obtained at Amity, I procured some small fragments with faces. When measured with the reflective goniometer, they gave constantly for the angles of the primary form 124° 30′ and 55° 30′. Prof. Shepard has thought this mineral to be coccolite, but these angles are different from those of augite.

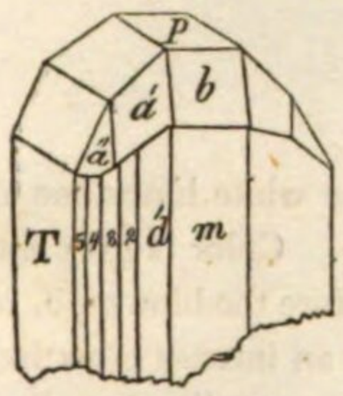
In the same mass was found a great number of minute crystals of blende, as is inferred from their cleavage, infusibility, lustre, and angles of 120° and 125° 15′, indicating planes of the rhombic dodecahedron and regular octohedron.

Minute red brilliant prisms with an adamantine lustre, were also observed in this pargasite. They were supposed from their aspect to be rutile, but no experiments were made.

6. YELLOW GARNET? of Edenville.

In the summer of 1828, I obtained at Edenville a yellowish brown crystallized mineral imbedded in white limestone, associated with pargasite and grey glassy tremolite. It resembles in external characters, and in its treatment with the blowpipe, the yellow garnet of Newton, New-Jersey, analyzed by Mr. Seybert. Specimens from Newton and Edenville both melt easily before the blowpipe, swelling out much, and forming a white fritty glass. A small brilliant crystal, mounted on the reflective goniometer, gave the following angles:

Fig. 32.



m on T .. 90°00′
m on b .. 141 40 to 141°48′
m on a' .. 138 10 to 138 20
b on a' .. 144 04 to 144 15
m on d^1 .. 160 30 to 160 34
m on d^2 .. 150 00
m on d^3 .. 146 00
m on d^4 .. 146 15
m on d^5 .. 123 12. The planes d^2, d^3, d^4, were not so brilliant as to give perfect reflections. The above angles approximate to modifications of the rhombic dodecahedron. Seybert's analysis gave the following as the composition of the Newton garnet:

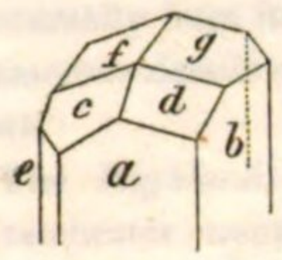
Silex	32.80
Lime	27.80
Protoxide of iron	27.56
Alumina	3.06
Magnesia	1.24
Manganese	6.32
Water	1.10
	99.88

7. SPECULAR OXIDE OF IRON. "TITANIFEROUS IRON."

This ore has been found in large detached crystals, at the locality of the large spinelles and of serpentine near Amity. It has been called *chromate of iron* by Dr. Fowler, because it colored nitre green;* and *specular iron* (*Fer oligiste*) by Shepard,† and *columbite*. It occurs in a gangue of serpentine which is sometimes crystallized, and is associated with spinelles, brucite, calcareous spar, etc. Its specific gravity in distilled water at 47° of Fahrenheit's thermometer, was 4·319. The following measurements were made with the common goniometer:

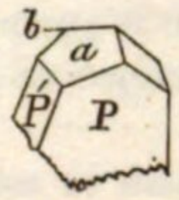
* American Journal of Science, Vol. 9, p. 243. † Ibid. Vol. 21, p. 329.

Fig. 33.



a on *b*,	122°30′	*a* on *b*′,	57°30′
a on *c*,	122 30		
a on *e*,	112 00	*a* on *e*′,	109 00
a on *g*,	55 40	*a*′ on *g*,	122 30
a on *f*,	71 30		108 30
b on *g*,	92 30	*b* on *e*′,	128 30
f on *g*,	124 30	*b*′ on *f*,	125 00*

Fig. 34.

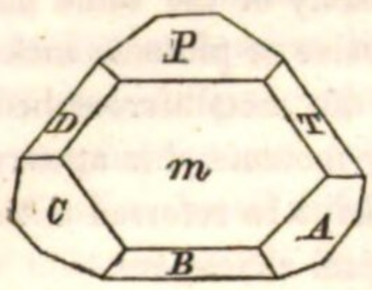


P on P′, 109°30′
P on *a*, 123 00
P′ on *a*, 126 00
P′ on *b*, 54 40

The edge of the plane *b* is seen at *b* in the figure.*

The above measurements were made in March, 1832. Prof. Torrey, when I was engaged on those measurements, sent me the results of some measurements that he had made in 1826. He made the specific gravity $\left\{\begin{matrix}4{\cdot}32\\4{\cdot}33\end{matrix}\right\}$. His measurements were as follows:

Fig. 35.



m on T,	108°	*m* on D′,	58° to 58½°	T′ on B′,	86°
T on T′,	129½ to ¾	*m*′ on A,	58	D′ on T′,	86
P on P′	130	*m*′ on P,	58	D on B′,	86
m′ on P′,	107½	*m* on T′,	58	P on B′,	93
A on A′,	131?	*m* on D,	108	A on T,	93*
m on B,	130	*m* on P,	123		
		m′ on T′,	123		
		m′ on D′,	122½		
		m on A,	122¾		
		D on D′,	123		

Some of the above measurements correspond with some of the modifications of the regular octohedron, in which one of the vertices is replaced by a plane, with another plane parallel to one of the diagonals of the base; and as such, might be referred to *franklinite*, if its composition would justify it. More of the angles measured correspond with modifications of the rhomboid of specular iron ore, to which it must undoubtedly be referred.

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* The letters used on these figures hove no reference to crystallographical notation.

CHAPTER IX.

PRIMARY ROCKS.

Under this term of Primary rocks, are included those usually called by that name, that have not yet been described as metamorphic, though some of them are probably of the same age as the Metamorphic rocks. This is particularly the case with the intrusive or plutonic rocks, as granite, sienite, hornblende rock, some of the trappean rocks, and the metalliferous beds and veins intertruded among these rocks, and that have been altered by metamorphic agency. The hornblendic gneiss, micaceous gneiss and mica slate may also perhaps be referred to the same periods, as having undergone marked changes in their mineralogical characters.

The Primary region embraces the counties of New-York, Westchester and Putnam, the southeast part of Dutchess, the west and northwest parts of Rockland, the southeast part of Orange, with a few islands of these rocks surrounded by others in Orange and Dutchess, and a very small part of Richmond county in the southern part of the First geological district; and the northern and northwestern parts of Saratoga and Washington counties in the northern part of that district.

The rocks in the Primary region are composed of the same kinds of rock, which are not very numerous; and each of these kinds is very similar in mineralogical characters, in mineral contents, and in geological associations.

The rocks of the Highland mountains, and of the mountains of Saratoga and Washington counties, are very similar, and different from those of the lower hills in Queens, New-York, and Westchester counties.

Although I have spent twelve years of my life in the midst of the Highlands, and although in the habit of spending most of my leisure during a part of that time in unravelling its complicated geological phenomena, I feel that I have but *begun* to develop those facts that are of high importance, not only in scientific, but in economical geology. The general geology is very simple, but when we come to examine particular strata, veins and beds of useful minerals, and trace out the connection of the different localities, it is found to require much time and an intimate practical knowledge of the subject. The strata, in many places, are transverse to the general direction of the strike of the rocks, in consequence of transverse upheaves, of which there are several striking examples. Again, faults are numerous, and in many of these the heaves are not only vertical but lateral, and sometimes to a distance of one thousand

to six thousand feet. These counties present one of the finest fields in our country for the investigations of physical geology. A lifetime might be well spent, and with advantage to the community from its economical results alone, in developing the geology of the Primary region. Numerous details on this region are omitted, as a volume would be required to elucidate the facts.

The *Highlands in Rockland and Orange* are a continuation of those of Putnam and Westchester counties, and are similar in general aspect, in the kinds of rocks, and in their mineral products. The rocks consist of gneiss, and hornblendic gneiss, granite, sienite, limestone, hornblende, serpentine, augite and trappean rocks. The strata dip to the southeast at angles from fifty to ninety degrees, but there are localities where the strike and dip are transverse to the general directions. The strata are intersected by seams transverse to the direction of the strata, and nearly perpendicular to the line of bearing, and at intervals of one hundred to ten thousand yards. Dislocations and vertical and lateral heaves have occurred along many of these lines of fracture. The outcropping edges of the strata are not parallel to the line of bearing, but like the ridges slope gradually down to the northeast; while on the southwest, steep escarpments range along the lines of faults. Many of these faults are upon an enormous scale, and render the tracing of narrow beds of rock of economical value a matter of no small difficulty. There are no continuous ridges of mountains of more than a few miles in length, in consequence of the interruptions caused by dislocations and lateral heaves of masses of the strata. The hills of similar rocks succeed each other in echelon lines, which seem to have been caused by lateral heaves along the lines of fault. In consequence of this, neither the line of outcrop nor the line of bearing is parallel to the general direction of the Highlands, but ridge succeeds ridge, each of which runs out and diminishes in height until it disappears below the rocks which are generally considered of more recent origin.

In Washington and Saratoga counties, the direction in which the ridges slope down and disappear is in the reverse direction from that in the south part of the State. In the southeast part of the State, the ridges present cliffs at their southern ends, and slope down gradually to the north, until they disappear and are succeeded by others; while in the north part of the First district, the ridges show cliffs and steep escarpments on their north ends, and slope gradually down towards the south until they disappear.

Local Details.

On *Staten island*, Richmond county, the rocks included in those now under consideration were seen in only one locality. The rock was granite, and was seen on the shore opposite Nautilus Hall, at the Quarantine. It is coarse grained, composed of white and smoky quartz, red and grey felspar, and mica. It is seen only over a space of a few square rods, and is covered by the deposits belonging to the erratic block group. It is not of a suitable texture for a building material, and cannot be applied to any useful purpose, except as a rough wall stone.

On *Long island*, rocks of this class were seen along the shore near Hurlgate, at the Hog's-back, and along the shore for half a mile, and in the village of Halletscove. They are mostly hornblende slate and hornblendic gneiss, in vertical strata, intersected in some places by veins of granite. Some of the strata are nearly pure hornblende. In the gneissoid hornblende and hornblende slate, the hornblende forms layers, and gives the rock a highly striped appearance. The layers and strata of hornblende are from one-twentieth of an inch to one foot in thickness. This rock, even in hand specimens, illustrates the striped aspect of gneiss in a striking and beautiful manner.

The island of New-York is underlaid by rocks of gneiss, micaceous gneiss, hornblendic gneiss, hornblende slate, hornblende rock, limestone, the anthophyllite rock, and granite. The rock in place crops out in almost every square acre on the hills in the north part of the island, and in many places along the shore of the Hudson and of the East river. The micaceous gneiss is the prevailing rock. The strata are nearly vertical, some dipping eastward, and some westward. The strike is also variable from northeast to northwest, but north-northeast is the prevailing direction. Granite in numerous beds and veins, some of which are very tortuous, were observed. A good example of this may be seen on the sides of the rock excavation for the approaches to the tunnel, on the railroad from New-York to Harlem. Very many interesting localities were observed where excavations had been made in quarrying, grading the streets, and where the rock was exposed on the surface; but the localities were not noted, as the detailed geology of the island was committed to Prof. L. D. Gale.* At Hurlgate ferry, at the east end of Eightysixth-street, the strata are vertical, and are of gneiss more or less micaceous and hornblendic, interlaminated with beds and irregular masses of granite. The strata are frequently bent, where these irregular masses of granite were observed. Pyrites are common in this gneiss, and in some places sulphate of iron is formed.

The following sketch by Prof. Gale, will give an idea of the general character of the rocks, their distribution, strike, dip, etc. on the island of New-York:

The *island of New-York* "is about twelve miles long, and from a half of a mile to two miles and a quarter broad.

"The basis rock of the island is *gneiss*, if we except about one mile in length of the northern extremity, which is limestone. The middle and northern portions are rough and broken from the almost constant exposure of the rock above the surface; while the southern, although consisting of the same material, is every where covered, and in some places to great depths, with alluvial and diluvial deposits.† The gneiss varies considerably in character in different portions of the island. For example, the northern part abounds largely in limestone, and the

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* It is to be regretted that Prof. Gale did not give more *details* of so interesting a region as the island of New-York. where excavations of the rocks exposed so many important facts, and where so many persons would be led to examine them. He has given us many details on the alluvion and drift, and it is to be hoped that he will at some future time give to the world the detailed observations he has made on the primary rocks.

† These have been described on pages 19, 134 to 139, and 179 to 183, under the heads of *Alluvion*, *Quaternary* and *Drift* deposits.

western in veins of granite and quartz; while the southern and eastern, as well as the middle portions, are more purely gneiss.

"The covering of the rock, in the southern part of the island, is in some places more than one hundred feet in depth, and consists generally of from ten to eighty feet of diluvium (loam, gravel, or boulders, one or all) on the surface, resting on the same or greater thickness of alluvial or tertiary sands, which last are highly stratified, and in many places even exhibit the appearance of ripples as from the retiring waves of the ocean. As we proceed northward, the deposits grow thinner and thinner, until the rock makes its appearance above the surface. This occurs on the east side of the island, between Thirteenth and Sixteenth-streets; and on the west, from Twentyninth to Thirtyfirst-street. The greatest thickness of diluvium is at the southeastern extremity, where it was accumulated in conical hills, some of which were seventy or eighty feet above the grading of the streets. The general direction of the strata corresponds very nearly with that of the avenues; and the dip, though generally to the west, averages within ten degrees of vertical. In speaking of different sections, the dip, on the west side, more especially from the city to Harlem valley, is, with few exceptions, vertical; and the same remark applies to the middle portions, as far east as to the Eighth avenue; while on the east side, from Fourth avenue to the river, the dip is quite irregular; varying from 45° W. to 45° E., although the composition is more uniformly gneiss, than in other portions of the island.

"In a few cases, it has been found that carbonate of lime enters into the composition of the rock of the island. This is the case on the east side of the Fourth avenue, from the 118th-street to the 120th-street. Here the rock retains its identity, as gneiss, to all appearance; although half of its mineral matter is carbonate of lime. Again, at 157th-street, and about one hundred feet west of Tenth avenue, the rock is entirely changed both in composition and structure. In composition, it is a mixture of limestone and serpentine; while in structure, it is destitute of strata, and lies in beds."

"The section lying between the settled portion of the city and the level valley extending from Manhattanville on the Hudson to Harlem on the East river, is generally bounded on the south by the outcropping of the gneiss, which, as before stated, commences on the west at Thirtyfirst-street on the Tenth avenue, at Twentyninth-street on the Ninth avenue, at Twenty-eighth-street on the Eighth avenue, at Twentyfourth-street on the Seventh avenue, at Twentieth-street on the Sixth avenue, and at Sixteenth-street on the Fifth avenue, where it comes within four feet of grading; on Thirteenth-street, between University place and Broadway, it again approaches within three feet of the surface; and on Fourth, Third and Second avenues, at their several junctions with Sixteenth-street, it appears at or above the surface; while on the First avenue, it crops out first at Twentyfirst-street, and continues as we progress to the northward on the banks of the East river, until we reach Ninetyfourth-street, which is at the eastern termination of Harlem flats, where the rock dips below the surface, leaving a salt marsh which from this point continues northward. Again commencing on the west side of the island, we find the rock continues from Thirtyfirst-street northward to Manhattanville, almost constantly above the surface at or near the water's edge.

"The elevated points of this section of the island vary from seventy to one hundred and twenty feet above tide-water mark, and will, when graded, give at a rough estimate a medium level of about forty feet above the contiguous waters. The valleys, however, are often deep, and the hills precipitous, rendering this section rough and broken.

"The Third, Fourth and Eighth avenues have been cut through until they reach the Harlem river; the first two terminate at Harlem, the other at M'Comb's dam; Fifth and Seventh avenues terminate at Twentyfirst-street; Sixth avenue extends to the Bloomingdale road at Thirtysecond-street; Tenth avenue to the same road at Seventieth-street, in the village of Bloomingdale; and Ninth avenue terminates at Fortysecond-street.

"The excavations for the above avenues have rendered geology an essential service by exposing the rocks of the island, and exhibiting their surfaces, their stratification, their mineral ingredients, and included minerals. The strata of the rock, as before stated (page 519), follow more generally the direction of the avenues, which run N. 35° E. Of about seventy-five observations on this section to ascertain the strike of the strata, more than fifty gave results varying from N. 25° E. to N. 35° E., making the medium strike N. 30° E. Two extremes were N. 45° E. and N. 45° W.

"The dip of the strata was taken in eighty-four different places on this section. Of these, twenty-nine were vertical, thirty-eight were to the west, and eight to the east. Of the thirty-eight which dip westward, twenty-four are between 80° west and vertical, seven between 70° west and 80° west, and three between 45° west and 70° west. Of the eight which dip eastward, six are from 80° east to vertical, and two are 45° east. Of the eighty-four observations, fifty-eight were within ten degrees of vertical, and only six gave an eastward dip. The result is, therefore, that the medium dip of all the rocks of this section is westward about eighty-five degrees.

"The quality of the rock which forms the substratum of this section does not differ much from that of other parts, whether north or south of it; therefore, with some few exceptions, a proper description of the rock as it occurs here, will answer for the whole.

"As to its components, it contains a large proportion of mica, a small proportion of quartz, and still less of felspar; but generally an abundance of iron pyrites (sulphur and iron) in very minute crystals, which, on exposure, are decomposed. The sulphur and the iron both take oxygen from the air, and the result is free sulphuric acid, copperas and iron rust. The first two combine in their agency to hasten the disintegration of the rock, and the third gives it a permanent ferruginous cast. In consequence of these ingredients, it is generally fissile, tender, and soon disintegrated on exposure, rendering it unfit for the purposes of building. In some cases, the rock is so highly charged with pyrites, that on exposure for a few days in a dry season, it becomes covered with copperas in the state of an efflorescent powder, exhibiting the appearance of white frost in an autumnal morning. This phenomenon I have repeatedly seen on the rocks at the Hellgate ferry. Besides the regular ingredients of gneiss, it occasionally happens that the mica is replaced, either wholly or in part, by hornblende; in which case its color is rendered darker, it is more compact in texture, and columnar in its

structure. This occurs on the Fourth avenue, in the railroad cut at the south opening of the tunnel.

"As before stated, the gneiss on the western side of the island so abounds with veins of granite parallel with the strata, that in many places they constitute the chief material of the rock; and will, I doubt not, at a future day, be wrought for useful purposes. This has indeed been the case to some extent. Many sloop-loads of stone cut for culverts and other faced work on the Croton aqueduct, have been prepared from the material furnished in opening the Tenth avenue, and delivered. It is a fair granite, specimens of which I have furnished and labelled 'Granite from Tenth avenue, near Fortyeighth-street.' The granite prevails more or less from Thirtyfirst-street on the west side, and from Twentyfourth-street in the middle, to Sixtieth-street on the north, and most of it runs out southwest of Bloomingdale road. I am fully convinced that in cutting through the streets and levelling the lots, a large amount of excellent building material will be furnished, and will be a source of profit at a future day.

"The stone furnished for the aqueduct was delivered at the dock near the place of consumption, at one dollar or one dollar and twelve and a half cents per cubic foot, dressed for the work; which, I was informed by one of the contractors, was about the same as it would cost to get them out and put them in shape, when equally good materials could be furnished on the spot. This circumstance is explained by the fact that those who furnish it were contractors with the corporation of the city for opening the avenues on the island, where they are paid a certain amount, not exceeding one dollar or one dollar and ten cents per cubic yard, for removing the stone out of the way, and are at liberty to make such use of it as they please. The cutting of the stone, therefore, after it is removed from the quarry, is the chief expense to the furnisher; this shows why it can be furnished at so low a rate. The amount paid by the corporation for removing loose earth varies from twelve to thirty cents per cubic yard, according to the nature of the earth to be removed, and the distance to be carried to get it out of the way; the most common price is eighteen cents, and the same price is paid for filling in valleys, whether with stone or earth; and if it is done by the load, as is frequently the case, nine cubic feet make a load for one horse.

"Where rough stone are furnished for basements and other rough work, they are delivered at one dollar a load, so that contractors sometimes get pay for excavating, and also for the material excavated, expense for carting excepted."

The anthophyllite rock of this section of the island has been described under the Metamorphic rocks.

The section of the island lying between the Harlem and Manhattanville valley and the northern extremity of the island, commences on the east side, "at the northern limits of Harlem village, a few hundred yards northwest of Harlem bridge, and at about 134th-street; and on the west side of the island at the village of Manhattanville, at about 128th-street, and extends in a northeasterly direction to Kingsbridge, a distance of not far from five miles. This section, though rough and broken, is less so than the northern part of the last described.

A considerable part of it is still covered with its native forests, though most of it is capable of tillage. The southern part extending northward as far as the ten-mile stone, taken as a whole, is more level than the northern; but from the ten-mile stone to the northern extremity, it may be considered as divided into three sections, the western, the middle, and the eastern. The western is a continuous ridge of gneiss from a quarter to half a mile in width, and from sixty to one hundred feet above the waters of the Hudson. The middle is a long narrow valley, commencing a little north of the ten-mile stone, continuing northward to Kingsbridge, and descending most of the way; it is in this valley the great Kingsbridge road passes. This valley is lined abundantly with boulders of sandstone, greenstone, and white limestone like that from Kingsbridge, with large quantities of sand and loam. On the western side of this valley the rocks of the western ridge are very precipitous, being in many places fifty or sixty feet perpendicular. The third, or eastern section, lying directly east of the Kingsbridge road, and nearly parallel with it, is a ridge of gneiss of some elevation, though inferior to the first or western ridge; and is covered to a very considerable depth on its western slope with transported materials, in which diluvial loam and boulders of greenstone and white limestone are most numerous, though many other varieties are to be seen. The eastern face of this ridge is precipitous, and borders on Harlem river or the intervening marshes. It is lower and shorter than the western, dipping down below the surface in the vicinity of 198th-street and the Tenth avenue.

"From the 198th to 204th-street, on the Kingsbridge road, a narrow valley is formed by an opening through the western ridge, and extending from the Hudson to Harlem river, in a northwest and southeast direction. Through this valley vast masses of diluvial loam and gravel, with sand and pebbles and boulders, have been transported and piled up in conical hills east of the road, and on the northern slope of the eastern ridge, which is covered by abundance of boulders of limestone, granite, greenstone and sandstone.

"At the northern part of this valley, and from thence to the northern extremity of the island, the road continues on the east side of the ridge, and in view of the East river, leaving all of the high grounds on the west. At this northern portion of the valley, and on the eastern slope of the ridge, the limestone generally called *Kingsbridge marble* commences, and continues to Kingsbridge, a distance of nearly a mile and a quarter. This marble, which has been chiefly wrought for burning into lime, is mostly of the variety called granular limestone; and is so loose in texture, that after exposure for a time to the weather, it falls to pieces, becoming a kind of calcareous sand. It belongs to the gneiss formation, as is evident from the commingling of the two in many places throughout the course of the limestone. At the junction of the two rocks, and often for a considerable distance into the marble, it retains the structure of gneiss with the mineral matter of limestone; but where the matter becomes pure limestone, it lies in beds without stratification, or but obscurely stratified.

"At the southern limit of the limestone, where it is from fifty to eighty yards in width, and about one hundred yards west of the road, the strike is N. 30° E., and the dip vertical. It is flanked on both sides by gneiss, and as it continues northerly in the direction of the strike

or bearing of the strata, it widens until it becomes from four hundred to six hundred yards in width, and from ten to thirty feet in height, forming a low ridge immediately west of the road, but east of the main ridge of gneiss which flanks the eastern shore of the Hudson, and which terminates at Tubby hook, about half a mile north of the commencement of the limestone. As the gneiss runs out at the mouth of the Spuytenduyvel creek, the whole ridge northward is limestone, the form and extent of which may be learned by inspecting the map of the island. The strike was examined in a number of places on the ridge of limestone, and varied from N. 25° E. to N. 45° E., and the dip from 50° E. to vertical. From Mr. Dykeman's house (which is near the southern line of the limestone), to the old tide-mill (which is nearly opposite to Tubby hook), at a distance half a mile or a little more, is a line of abandoned quarries, which many years ago were extensively wrought for burning into lime; but as the lime was of inferior quality, other varieties at length superseded it. This limestone has been called dolomite, but whether from its granular structure, or from its composition, I am unable to determine. I have not met with any analysis of it, nor do I think there is any on record.

"The extreme eastern part of this section lies east of the three divisions already considered, and is bounded east and north by the Harlem river, west by the valley of the Eighth avenue, and on the south by Harlem and Manhattanville valley. It terminates on the north at M'Comb's dam, about one mile north of the Harlem bridge, and consists of a low ridge of gneiss, following the line of the Seventh avenue. It is from two hundred to four hundred feet wide, and from fifty to eighty feet above the contiguous plains. The valley through which the Eighth avenue passes is throughout its course a perfect level, and but a few feet above the waters of the river. The strike of the strata of this ridge at 142d-street is N. 25° E., and the dip vertical. In the extreme north, at M'Comb's dam, the gneiss crops out. It has the strike N. 35° E., and the dip vertical; and is covered in many places to the depth of fifteen or twenty feet with the diluvium, consisting of loam, sand, gravel and pebbles, with boulders of white limestone like that of Kingsbridge, greenstone like that of the Palisades, sandstone and granite. The granite is generally rough and angular; while most of the others, especially greenstone, are rounded and smooth. In this vicinity the general course of the river, as well as the valley through which it runs, is south-southeast; so that any current from the northwest would be likely to accumulate any materials swept along in its course, on such prominences as that at M'Comb's dam."*

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* Prof. L. D. GALE's Report to W. W. MATHER, on the Geology of New-York Island, in the Third Annual Geological Report of New-York, 1839, p. 177, 184.

"*The minerals enumerated: 1st, those belonging to the island; 2d, those from other sources.*

I. THOSE BELONGING TO THE ISLAND OF NEW-YORK.

1. *Quartz crystals* (inferior specimens). Small crystals, in the Harlem railroad cut, under the track, in veins of gneiss, about 122d-street.
2. *Rose quartz* (inferior specimens). From the same place; the locality being covered up, no more specimens can be obtained.
3. *Epidote.* Very small crystals of a deep green color, in hexagonal prisms, in veins of half an inch wide, in gneiss, at Thirtyeighth-street, on the banks of the East river, in the southeast part of a gneiss quarry.
4. *Tourmaline.* In hexagonal prisms, in granite beds or veins in various parts of the island. Many fine specimens were obtained in opening the Harlem railroad.
5. *Brown garnets.* With twenty-four trapezoidal faces, very imperfect; abundant in the gneiss on the shore of the Hudson, between Fortysecond and Fiftieth-streets, and in boulders in every section of the island.
6. *Hydrous anthophyllite.* Already described; very abundant.
7. *Serpentine.* Intermixed with white limestone, and of granular structure; described with the last, and from the same locality.
8. *Red stilbite.* In small quantities, in veins of gneiss; in small scopiform fibres of a reddish yellow color. From the railroad cut near the tunnel; the locality is exhausted.
9. *White pyroxene.* In four-sided tables, in veins in limestone at the abandoned quarries at Kingsbridge, at about 208th-street, five rods west of the Kingsbridge road.
10. *Fetid felspar.* Of a bluish white color, in tabular masses in limestone at Kingsbridge, Thompson's quarry near 196th-street, and about one hundred yards west of the road.
11. *Iron pyrites.* In exceedingly small cubic crystals, throughout the island, in the gneiss and in the limestone at Kingsbridge.
12. *Tremolite, white.* In the abandoned quarries of limestone at 208th-street, west of Kingsbridge road.

II. THOSE FROM OTHER SOURCES.

1. *Mesotype.* In cavities and veins in greenstone.
2. *Datholite.* From the same source.
3. *Apophyllite.* Also from same source.
4. *Chlorite.* Same source; found in small quantities.

"All of this last class have been found in small quantities in veins in the boulders of greenstone, barely sufficient to determine their characters."*

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* Prof. L. D. GALE, Third Annual Geological Report of New-York, 1839, p. 96, 97.

(A.) PRIMARY ROCKS OF NEW-YORK, WESTCHESTER, DUTCHESS AND PUTNAM COUNTIES.

The rocks of these counties are numerous, many of them are applied to useful purposes, and they are every where abundant, and are seen cropping out from the surface of almost every hill and ravine. The principal rocks are,

1. Granite.
2. Sienite.
3. Gneiss.
4. Mica slate.
5. Augite rock.
6. Greenstone and hornblende rocks.
7. Quartz rock.
8. Talcose slate.
9. Limestone.
10. Serpentine.
11. Steatite.

The five latter rocks have already been described as Metamorphic rocks. The others remain to be described.

1. Granite.

This rock occurs abundantly in New-York, Westchester, Dutchess and Putnam counties. It presents all varieties of texture, from a very coarse grained rock, to one almost perfectly compact. In color it varies as much as in texture. It is white, red, grey, yellowish and bluish grey, according to the color of the minerals forming it. The color of the felspar usually determines that of the mass. It occurs in beds, in veins, in interstratified masses, and in knots, knobs, and protruding masses, in which no connection with veins or beds have been traced. The more common mode of its occurrence is in beds ten to one hundred feet thick, interstratified with gneiss. Some of the granite is too coarse for use as a building material. Some is too compact and hard, being, in fact, *eurite;* others are well adapted for building. Different localities show a great variety in strength, and in the ease or difficulty of dressing, as well as in the ease of quarrying and the magnitude of the blocks that can be procured. In the Geological Report of 1838, it was mentioned that many places would undoubtedly be found in the Highlands, where fine quarries would be opened, and furnish "building materials of the best quality, and which would endure the changes of our variable climate for ages without decay or disintegration." The investigations subsequent to that time have verified the prediction that such localities might be found. The materials are of the best quality, easily quarried in large blocks, suitable for columns, cornices, etc., easily dressed, enduring as time, as the naked crags themselves will testify; and several of the localities,

which were unknown to their owners, are so convenient to water transport that the blocks can be swung directly on board vessels in the Hudson, by means of cranes. When we consider the value attached to the quarries in Maine, Massachusetts and Connecticut, where, in most places, it is necessary to haul the stone, either on a common road, or construct a railway to navigable water, a distance from half a mile to six or seven miles, and observe that notwithstanding all these disadvantages, the great outlay of capital, and the distance to a market, they make it a profitable business, we may begin to appreciate the importance of having inexhaustible quantities of materials, as good, as beautiful, as durable, and as easily quarried and dressed, on our own waters, within forty or sixty miles of the city of New-York, and so convenient to shipment that no railroads and hauling are required.

Blunt's quarry. This is located on the south side of Breakneck point, near the line between Putnam and Dutchess counties. There is an inexhaustible supply of a material of the best quality. It is a bluish grey granitic rock, composed mostly of a dark colored felspar, with some hornblende, quartz, and occasionally a little mica. It is more properly sienite than granite. It is scarcely as dark as the Quincy granite or sienite, while it is as beautiful, has about the same strength, splits as well, and is as easily dressed. The stone from this quarry has been extensively used in the construction of the Delaware Breakwater, of Fort Calhoun and Fortress Monroe. The mountain rock has not been quarried at this place, but only the large masses that have tumbled from the cliffs above. It is not possible to give an accurate estimate of the quantity of granite in this vicinity, but there may be in the end of the mountain five hundred acres, with an average depth of five hundred feet, or 803,640 cubic yards to the acre, or 401,720,000 cubic yards on five hundred acres.

Blunt's quarry is located on the immediate shore of the Hudson river; but on account of the flats, the stone has been hauled about sixty rods to a landing. This quarry bids fair to become valuable; but there is one disadvantage that *may perhaps* operate as a drawback to its advantageous position. It is overhung by a precipice of several hundred feet in height; and in the quarrying operations, the heavy blasts may bring down hundreds of thousands of tons of rock which can be useful only for dock stone and ballast.

Highland Granite Company's quarry. This quarry is principally owned by Messrs. Howard & Holden. It is located one-fourth of a mile from the Hudson river, and half a mile east of Blunt's quarry near Breakneck point, and about two miles from Coldspring. It is elevated about four hundred feet above the Hudson, in full view of the river. The stone is of excellent quality, and splits easily into large blocks. It is composed principally of felspar, with a little hornblende, and is indistinctly stratified; or at least it lies in thick heavy beds with parallel seams six to twelve feet apart, and which are slightly inclined to the horizon. The quarry is inexhaustible, and ought to be very valuable. This quarry is on part of the bed of granitic rock described under Blunt's quarry. The stone is now hauled to the landing, about one-fourth of a mile, at an expense of three cents per cubic foot, or forty-two cents per ton. Much of it is sent to Singsing, for the culverts and aqueduct bridges; and the freight to that place is four cents per foot, or fifty-six cents per ton. It is delivered at Singsing in blocks of

ten cubic feet and over, at thirty-five cents per cubic foot, or five dollars and ninety cents per ton. The dressing of this stone for the arches is done at fourteen and a half cents per superficial foot; and about two and a half superficial feet are dressed to the cubic foot, which make the stone dressed, ready for the arches, cost seventy cents per cubic foot, or nine dollars and ninety-seven and a half cents per ton.

This quarry is capable of being worked at least seventy yards in depth, over an area of several acres; and allowing a profit of one dollar per cubic yard, which is a low estimate, and 4840 square yards to the acre, fifty yards in depth ought, in the course of working, to give a profit of 242,000 dollars to the acre.

Stony point, one mile northwest of Coldspring, Putnam county. This is a rocky peninsula, stretching into the Hudson about one-fourth of a mile. It is composed of gneissoid rocks, except the northwest point of the peninsula, which is a granitic rock of the same character as that of Blunt's and the Highland Company's quarries. About two acres of this peninsula are covered by this rock, to an estimated mean depth of forty-five feet above high-water mark; and it may be estimated that there are 145,200 cubic yards of granite capable of exploration on this point. It may apparently be split out in masses of any size, up to one hundred tons or more, in regular blocks; and it lies immediately on the Hudson river, and with such a depth of water that large vessels may come immediately alongside of the rocks to be quarried, so that the blocks may be swung on board with a crane.

Stony point is owned by Mr. Phillips of Phillipstown, who was not aware of the existence of such a location for a granite quarry, until he was informed of it during the progress of the survey of Putnam county in 1840.

Phillips's quarry. This belongs to the same gentleman as the preceding. It is located on the Phillips estate, about half a mile from the Hudson river, and one and a half miles east-northeast of West-Point. The rock is perfectly indestructible, and would be called granite by those who should see the blocks without seeing the quarry. It is gneiss, in thick layers or plates, which have a slight inclination to the west, while the grain of the rock is nearly vertical. It splits easily, both in the direction of the grain and across it. It may be procured in the form of blocks of five to ten or more feet square, and of the thickness of the plates of rock, which are from one to four feet thick. Some masses were seen which had been split off for columns for store fronts, twelve to fourteen feet long, by one and a half, one and three fourths, and two feet square.

The rock at this quarry is of a light grey color, almost white, and is a beautiful material for building. It is durable, of sufficient strength, easily dressed and easily quarried, and the stone can be transported to the banks of the Hudson for three to four cents per cubic foot.

The extent of this rock was not ascertained; but there is an area of at least ten acres, with a mean depth of sixty feet, or 26,136,000 cubic feet, or 968,000 cubic yards of this granitic gneiss, or about 1,900,000 tons.

There is a location suitable for quarrying in Putnam county, about three and a half miles

below West-Point, and near the Cotton rock. The granite or granitic gneiss is of good quality, of a light grey color, and durable. This locality was not examined closely; but from the general aspect of the rock, it is believed to be a good location for a quarry.

There are two locations for fine granite quarries on the estate of Gen. Van Cortlandt, on the shore of the Hudson in Westchester county, between Anthony's Nose and Peekskill. The granite has the appearance of stone of superior quality, perfectly indestructible, and has every external aspect of quarrying easily in large blocks. It is inexhaustible in quantity, and lies upon the shore of the Hudson river, with deep water alongside, so that the facilities for shipment are almost unrivalled.

Beautiful light grey granite was seen in abundance from one to two and a half miles northwest of Boyd's corners. It is as durable as time, and may be procured in any quantity, but its distance from easy transportation by water or railroad will prevent its use at present beyond the neighborhood.

It is estimated that several millions of dollars are annually paid out of the city of New-York, and the towns on the Hudson river, for building stone, brought from beyond the limits of the State; while we have within our own boundaries, and near the markets, inexhaustible supplies, of equally good quality, which can be quarried, shipped and hauled at less expense than the stone we now import from Maine, New-Hampshire, Massachusetts and Connecticut. The granites of the Hudson river *must*, then, soon be wrought and sent to market, and the quarries will become very valuable.

2. Sienite.

This rock abounds in some parts of Westchester and Putnam counties. In Westchester county, it approaches in its characters to the "Quincy granite" of Massachusetts, and would probably make as beautiful and durable a material for building as that which is justly so celebrated. In Putnam the sienite is generally coarse grained, of a reddish color, spotted with black crystalline and irregular masses of hornblende. This rock passes into hornblende slate and hornblende gneiss on the one hand, and into hornblende rock on the other. No localities were seen in Putnam county where this rock would be available for economical uses, except the granitic seinite, which has already been mentioned under the head of granite, as occurring in Breakneck mountain, and at Stony point above Coldspring.*

The sienite of Westchester county is composed of felspar of a dark greyish color, containing a little black hornblende. It forms the shore of Peekskill bay of the Hudson river, from about one-half mile to one and a half miles below Peekskill, on the eastern side of the bay. It forms the mass of some of the hills for four or five miles southeast of Peekskill, and valua-

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* The mountain at the northwest corner of Putnam county is frequently called *Anthony's Nose* and *Anthony's Face*, in consequence of the profile bearing a rude resemblance to the human face, that may be seen in one position in passing it; but *Breakneck mountain* is the name by which it is generally known. Anthony's Nose mountain is at the southwest corner of Putnam county, opposite Fort Montgomery. Stony point, above Coldspring, I propose to call *Quarry point*, to distinguish it from Stony point in Rockland county, a place of much notoriety in the annals of the revolution.

ble quarries of this rock may be opened, if it can be brought into notice and use. It is a durable and beautiful stone, and may be procured in large blocks, but it is more labor to dress it than many of the granites and sienites sent to market.

The same rock, east of Verplanck, is changed to a black hornblende rock, with but little felspar, and it contains magnetic oxide of iron disseminated in grains. One mile east of Verplanck, it is coarsely crystalline and jet black. Beautiful specimens of hornblende may be obtained there. The jet black color of this mineral has caused excavations to be made in these hills to find coal;* a search that every one, who knows any thing of the associations of minerals with each other, would at once know was perfectly fruitless. The great weight of the hornblende has induced others to suppose that iron ore would be found here, which is possible, though no workable beds have been as yet discovered. In many places there is so much magnetic oxide of iron in the hornblende, that the magnetic needle will not traverse freely in the vicinity of the beds. Where the hornblende is decomposed, a deep red soil is produced, colored by the oxide of iron, and which is highly productive under judicious treatment.

The sienite rock of the *Highlands* is of two kinds. One is a coarse granitic aggregate of white or reddish felspar and black hornblende, sometimes also containing epidote and grains of magnetic oxide of iron, like that at the base of Bull hill one and a half miles north-northwest of Coldspring village, on the shore of the Hudson; and at the Target rock on Constitution island, opposite West-Point; the other is composed mostly of felspar of a dark greenish or sometimes yellowish and brownish color, with some quartz and hornblende. The latter is black or green, and sometimes passes into that described under the name of hornblende rock, where the hornblende is arranged in stripes through the rock. The felspar in this kind of sienite is occasionally opalescent, but is distinct in characters from that from the north part of the State, and which is seen in boulders and blocks on the slopes of the mountains in the Highlands.

3. Gneiss.

Gneiss is the predominant rock in New-York, Westchester and Putnam counties. It varies greatly in external aspect and in composition, in different parts of the tract under investigation. Its color is dependent upon the relative abundance of its constituents, which are variously colored in different localities. The felspar is white, reddish, or of a bluish grey; the mica is black, brown, yellow, copper-colored, and white; the quartz is white, grey or smoky. In some places mica abounds in the rock, and it approaches to mica slate, but more commonly the felspar is most abundant, and gives character to the rock.

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* Another excavation for coal was made near the landing at Peekskill. It was in gneiss in which there was a seam of plumbago, or black lead, mixed with pyrites. It would burn for a time, in consequence of the carbon and sulphur, but was not adapted for a combustible, even had there been an abundance of it. A great noise was made in the papers for a time, but the miners soon lost the vein by sinking the shaft vertically, while the seam of plumbago followed the layers of the strata parallel to the dip.

Much of the gneiss in the Highlands of the counties under consideration is a hornblendic gneiss, in which the mica is wholly or in part replaced by hornblende.

A range of granitic gneiss, of a light color, passes through Putnam and a part of Westchester county. It extends through Carmel, near Pine pond, by Mahopack pond; thence southwardly, and crosses the turnpike from Peekskill to Danbury. Another bed extends from Boyd's corners in Putnam county, and crosses the Peekskill and Danbury turnpike about five or six miles from the former place. These beds are quarried, to a small extent, for use in the vicinity; but they are too remote from water transport, for quarrying at present for a more distant market. It is durable, of a light grey color, easily split from the quarry, and easily dressed. If these strata reach the Hudson river, they are believed to have changed so much in aspect and quality as building stone, as not to have been recognized as the same beds. The bluish gneiss is quarried at Gen. Van Cortlandt's quarry, near Roya hook, two miles west of Peekskill. The strata here dip thirty or forty degrees to the east-southeast, and are interlaminated with beds of reddish and grey granite. Another quarry is opened near Peekskill landing, half a mile northwest.

A range of reddish gneiss extends north-northeast from the point above Tarrytown. In many places excellent quarries may be opened, where the stone quarries well, dresses easily, and is beautiful and durable for architectural purposes. One quarry is already worked to some extent in this range, for the New-York market, on Mrs. Beekman's farm, about one and a half miles from Tarrytown. Large quantities of stone are taken from this quarry, to be used in the construction of the culverts and bridges of the aqueduct that leads from the Croton river to supply the city of New-York with water.

Numerous other quarries have been opened along the line of the aqueduct, in the bed of gneiss just spoken of, and in others, to supply stone for this great work. It is not doubted that several of these quarries, which lie near water transport, will be wrought for the New-York and other markets. Our citizens do not yet appreciate the prospective value of good quarries on the banks of the Hudson river.

Another range of gneiss, suitable in many places for quarrying, extends from near Manhattanville on New-York island, by Whiteplains, and so on north-northeast, probably into Connecticut, or Putnam county. It enters the valley of the Bronx river about eight or nine miles below Whiteplains, while it forms a part of the range of the hills on the right bank of that stream for several miles below.

At one locality in this range, the rock is quarried to some extent, to furnish the stone for the aqueduct bridge across Mill river, near Yonkers or Phillipsburgh. It is an excellent, beautiful stone, but rather hard to dress. This stone will last as long as it will be required to endure, and it seems indestructible.

A gneiss quarry has been opened two miles east of Yonkers, on the land of Elijah Valentine. The rock is of a superior quality, and is used in the construction of arches in the aqueduct. The proprietor receives a rent of twelve and a half cents per cubic yard for the stone.

Gneiss, both fissile and thick-bedded, was seen at the landing at New-Rochelle, and on

several of the small islands of that vicinity. These and the associated hornblende rocks are like those on the island of New-York, and at Hurlgate near Hallet's cove.

The gneiss and granitic rocks of the west shore of Westchester county have been described while treating of the Metamorphic rocks, as associated with the white limestones.

4. Mica Slate.

This rock has a very limited distribution in New-York, Westchester and Putnam counties. Where it does occur, it seems to be a modification of gneiss, the mica becoming predominent, while within a short distance the rock resumes its characters of gneiss. No locality was observed where there is a prospect of valuable quarries of flagging stone of this kind of rock being opened, near water transport. A locality of mica slate, well characterized and fissile, may be seen, forming a point in Haverstraw bay, half to one mile northwestwardly from Henry I. Cruger's mansion. This rock assumes the characters of gneiss two or three miles north-northeast of the point above referred to, and thence continues its course in the line of bearing of the strata.

5. Augite Rock.

This rock occurs in a great number of localities in Putnam county, and in a few in Westchester county. It is sometimes intermixed with felspar, but more commonly it is either by itself, or mixed with the various minerals that are usually associated with it. It occurs at most of the celebrated mineral localities in the Highlands. It is of all shades of color, from white through grey and green of various shades to black, and from compact through various grades of granular to broad foliated masses, in the forms of fassaite, coccolite, common augite, sahlite, crystallized augite and diopside. This rock has not been applied to any useful purpose.

It is believed that this rock might with propriety have been described among the Metamorphic rocks. It has rarely been found except in connection with such rocks, and is almost constantly associated with scapolite, granular limestone and hornblende. It generally also, in Putnam county, has manganesian garnet and plumbago associated. This rock forms extensive masses between Anthony's Nose and Sugarloaf mountains, along the eastern side of the Hudson, between the shore and the base of the mountains.

Between the "Old silver mine" and the Hudson about four or five miles south of West-Point, it contains large quantities of crystallized, massive and granular manganesian garnet. The augite is dark green, and sometimes black, containing plates and hexagonal scales of plumbago. This rock scarcely corresponds with augite rock as described in systems of geology, as it does not generally contain *felspar*. Most frequently it is an aggregate of augite and scapolite, augite and carbonate of lime, or augite and manganesian garnet, and sometimes augite and mica.

A locality of white or rather grey augite, may be examined on the shore of the Hudson about opposite Buttermilk falls, and two miles southeast of West-Point, a little above the

point from which Arnold escaped. The augite here forms a heavy bed in gneiss rock associated with limestone. The augite is crystalline, grey, and contains scales and hexagonal plates of plumbago. A vein of a mineral that I suppose to be the pyrophyllite, traverses the augite rock. The mineral from this locality has the aspect of silvery mica, which can be dug out of the vein in masses so as to give plates of two or three inches in diameter, in rhombic and hexagonal crystals like mica; but the plates have not so much elasticity as mica, nor so much unctuosity as talc. The plates of this mineral, when heated, exfoliate, and spread out like the vermiculite of Rhode-Island, so that a plate of an eighth of an inch thick before being heated, becomes one-half to one and a half inches thick in the fire, the laminæ all separating, but remaining still attached to each other.

Another interesting locality of augite rock is on Anthony's Nose mountain, at the "White mine." It is here associated with a bed of brown spar, containing magnetic oxide of iron and plumbago. An ore of cerium is supposed to have been observed at this place.

Rocks of augite containing scapolite and sphene, were seen in many places on the shore of the Hudson at the southern base of Anthony's Nose mountain, but the localities from which they had fallen in the cliffs above were not traced out.

Augite containing sphene, scapolite, and associated with verd antique, diallage and hornblende, occurs at the base of the cliffs of Bull hill, near the shore of the Hudson; but the beds from which they had fallen, although some explorations were made, were not seen. The augite occurs under various forms, as green, yellowish, grey, crystalline, crystallized granular (coccolite of white, green, grey, yellowish and red), fibrous, and in acicular crystals.

Augite also occurs at Hustis's quarry in Phillipstown, as augite, white and green coccolite, diopside and sahlite.

Coldspring was an interesting locality of augite rock some years ago, but a block of buildings has been raised over the locality where so many beautiful specimens were procured. The augite rock is there associated with gneiss and granite, and contains scapolite and sphene in abundance. The largest and most beautiful crystals of sphene I have ever seen were obtained at this place by Dr. Barratt in 1822, now of Middletown, Connecticut. Augite is so common a rock in Putnam county, that it is unnecessary to multiply localities.

In Westchester county, it was seen more rarely. It has been mentioned as occurring at the Kingsbridge marble quarries, but it is not abundant. It was observed in the limestone in Mount-Pleasant, near the granitic rocks in the vicinity of the copper mine adit at Sparta, and in the cliff on the shore one hundred or two hundred yards south of Sparta, where the transverse heave has shifted the dip of the rocks.

6. Greenstone.

This rock traverses the strata in many places in Putnam and Westchester counties. In some places it has the aspect of compact trap, like basalt, but more frequently the hornblende predominates and gives its characters to the rock. It traverses, and is intertruded in sheets and irregular masses among the gneiss and other rocks in the same way as granite and sienite;

and many of the masses classed with this rock would be classed with sienite, but for the fineness of the grain, being of about the texture of a sandstone, composed of black hornblende with grains of white and grey felspar.

Well characterized dykes of greenstone of the basaltic kind were seen in a few places in Putnam county. One was near the mills northeast of Hustis's quarry; and another near the road from Coldspring to Davenport's corners, about two and a half miles from the former place.

The speckled greenstone in which hornblende prevails, may be seen abundantly in almost every part of the Highlands of Putnam and Orange counties.

Hornblendic Rocks.

This is a convenient repository for those rocks that are not so perfectly characterized as to be included under the preceding heads. Hornblendic rocks form a very considerable proportion of the mass of the Highlands in Putnam, and in fact in Rockland and Orange counties; but those parts composed of sienite, hornblendic gneiss, hornblende slate, and greenstone, have been described. Perhaps the remainder classed under this head might properly have been described as greenstone, for they have the geological relations of that rock, being evidently in many instances an intrusive rock; but very frequently it is almost pure hornblende, and could not, in conformity with the generally received composition of greenstone, be described as such.

Hornblendic rocks of this character occur near the "marble quarry" where such a variety of magnesian minerals occur associated with serpentine, near New-Rochelle, in Westchester county. Manganesian garnet also occurs in the hornblende, which is strongly crystalline and resplendent.

It has been mentioned as common on the shore of the Hudson between Peekskill and Yonkers, while tracing the connections of the white metamorphic limestones. It is particularly well characterized about one mile east and southeast of Verplanck's point, where the hornblende is strongly crystalline and resplendent. This rock extends some miles to the north-northeast, and forms very considerable masses. It is often interlaminated with the gneiss.*

At Verplanck's point, it forms veins, strings, and interlaminated masses among the limestone, and is an instructive locality.

Hornblende rock is abundant in Anthony's Nose mountain, between Anthony's Nose and Roya hook. Hornblende forms a constituent of a large share of the rocks of this mountain.

Hornblende is also common between Anthony's Nose and Sugarloaf mountains.

Greenstone, hornblendic gneiss, and hornblende rock occur at the northern base of the hill

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* This hornblendic rock assumes in the same mass the characters of sienite, "primitive greenstone," hornblende rock, hornblendic gneiss, and hornblende slate. It is sometimes distinctly stratified, sometimes perfectly granitic in its texture, and is composed of a dark brownish felspar, black hornblende, and black mica. They all seem contemporaneous.

at the laumonite locality,* about one hundred to two hundred yards below Phillips's mill, one and a quarter miles east-northeast of West-Point.

The hornblende rock is common on Bull hill, the mountain north of Coldspring.

The same rock, associated with hornblendic gneiss, was observed on Mount Stessing, near Pineplains, Dutchess county; and on the mountains in Pawlings, in the southeast part of Dutchess county.

The hornblendic rocks are constantly associated with the beds of magnetic oxide of iron, which are so numerous in the Highlands.

(B). PRIMARY ROCKS OF ORANGE AND ROCKLAND COUNTIES.

"The Primitive region of Orange county extends from Butter hill in the town of Cornwall, along the Hudson river to Fort Montgomery; thence along the line of Rockland county, to the State of New-Jersey; thence along the New-Jersey line, to the western base of the Pochunk mountain, about one mile southeast of the Walkill.

"The northwestern border of the primitive is very irregular, extending obliquely across the county near its middle, in a direction about east and west. It embraces a large portion of the town of Warwick, most of the town of Monroe, the south corner of Goshen, part of Blooming-grove, nearly all Cornwall, and parts of New-Windsor and Newburgh. By far the greatest part of this primitive region is composed of gneiss. In many places it is regularly stratified, the line of bearing being on an average S. 45° to 50° W. and N. 45° to 50° E., and the dip to the south and east at an angle varying from forty-five degrees to nearly vertical. There are, however, many variations, both in the direction and the dip, but they are local. This rock, in some of its varieties, forms the great mass of the Highlands. For exhibitions of the stratification and dip, many fine examples are seen on the Orange turnpike, and on the turnpike from Canterbury to the New-Jersey line. The local variations may be observed at Sterling mine, and on the road from Canterbury to West-Point, and many other places. It is presumed that the variations in the dip, to be seen on the last mentioned route, induced Prof. Eaton to believe that all the primitive rocks of the Highlands in this county dipped to the northwest.† *In general,* the primitive rocks of the county are less regular in

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* This locality of laumonite and stilbite has been said to be exhausted. It is not. It is a vein of decomposing felspar, two and a half to four feet wide, in which the laumonite and stilbite crystals abound. I had a blast put in the vein in 1829, and obtained an abundance of specimens showing these small but perfect crystals, in groups, in the cavities of the felspar. Many wagon loads could probably be obtained. Much of the felspar is dark-colored glassy felspar.

† Vide American Journal of Science.

stratification and dip along the banks of the Hudson, and at their western margin, than in their centre. Among the varieties of gneiss in the county, may be mentioned that in which the mica predominates, and that in which the felspar predominates, as being most abundant; these occur every where. Next in abundance is that which is called hornblendic gneiss and gneissoid hornblende, the hornblende and mica forming the larger proportion of the rock. It is very abundant at Long and Sterling mines, and in all the short ridges and elevations forming the western border of the Highlands. Granite is abundant in the primitive region of the county, constituting beds and veins. It is coarse and crystalline, on the road from Buttermilk falls to Fort Montgomery, and on the turnpike from Monroe works to Haverstraw. It is graphic on Rocky hill in Warwick, and other places. It is sienitic in Mount Eve, at Sterling iron mine, and many other places. It is compact in Butter hill, fine-grained and compact in many places on the road from Warwick to the Ramapo river. All the varieties of color are abundant. The red is particularly so in several of the ridges east of Long pond. While it is not positively asserted that granite, in this county, is a rock regularly stratified like the gneiss, the careful attention of geologists is invited to a locality on the northeast side of the turnpike from Haverstraw to Monroe works, about three miles from the latter place; also to many places on the turnpike from the saw-works to Bellvale, in Warwick.

"Immense quantities of rock are found every where in the Highlands of Orange, which are neither perfect granite or gneiss, but partake of the characters of both, or is intermediate between the two; and it is this *granitic* gneiss or *gneissoid* granite, which embraces a large number of the metalliferous deposits found in the county."*

The Primary region of Rockland county extends from the northeast corner near Fort Montgomery, along the Hudson to below Caldwell's landing; thence south-southwest along the base of the Highlands to the New-Jersey line, embracing all the county west and south of the line thus drawn, to Orange county on the west, and New-Jersey on the south. The islands called Wagon's islands, in the Horserace, between Fort Montgomery and Caldwell's landing, are also of the Primary rocks. Stony point, which lies east of the Taconic slate and limestone, belongs to this class of rocks.

1. Granite.

This rock abounds in Rockland and Orange counties. It occurs in beds, in thick intertruded masses, veins, and irregular masses, forming hills, and often the tops of the mountains. The beds and interlaminated masses often present the general aspect of gneiss, and it has sometimes been called stratified granite.

Locations suitable for quarries.

Granite and granitic gneiss, suitable for quarrying, occur at the foot of Butter hill and of the Crow's Nest.

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* Dr. W. Horton, Third American Geological Report of New-York, 1839, pp. 136, 137.

A granite quarry might be opened with advantage on the shore, about one mile south of Fort Montgomery, and east of Mrs. Pell's house.

Several quarries can be opened on Wagon's islands, between Fort Montgomery and Caldwell's landing.

One or more quarries can be opened at the foot of the Dunderberg mountain, between Caldwell's landing and Wagon's islands.

These quarries may all be opened directly on the shore, and blocks of large size may apparently be quarried with ease, and swung directly on board vessels by means of cranes. Should these stones prove as good as their external aspect would seem to indicate, it would be difficult to estimate their value, which would be very great.

A valuable quarry may be opened on Stony point, a little west of the light-house. This part of Stony point next the United States' land, belongs to Mr. Brewster. There are about ten acres of granite of good quality, and which may be worked to a mean depth of sixty feet to high-water mark. This place ought to be able to furnish one million cubic yards of granite, or 27,000,000 cubic feet. This rock is the proper granite, composed of quartz, felspar and mica. It is darker or as dark colored as the Quincy stone; is as durable, and as easily dressed. This quarry ought in the course of working to yield a nett profit of one million dollars, if the stone should prove as sound and easily quarried as its appearance would seem to indicate. The aggregate amount of workable granite in locations just described on the right bank of the Hudson in the Highlands, is estimated at 100,000,000 cubic yards, or 2,700,000,000 cubic feet, a quantity that may be considered inexhaustible.

Granite veins. These are very numerous, and may be seen in every quarry, and in every cliff and naked surface of the rock exposed to view. Some are very tortuous, others nearly straight and smooth on the sides, but most generally they are very irregular, and connected with intertruded and interlaminated irregular masses and beds of granite in the gneissoid rocks. The granite in the veins is of much finer grain and texture than that of the large masses and beds. Minerals are rarely found in them, except quartz, felspar and mica. Garnets, hornblende, epidote, sulphuret of molybdenum, pyrites, etc. are *occasionally* seen in the veins. Numerous fine examples of veins, beds and irregular masses of granite may be seen at and near West-Point.

2. Sienite.

This rock occurs abundantly in the Highlands. It is usually a coarse granitic aggregate, composed mostly of whitish or reddish felspar, and containing masses of hornblende, intermixed sometimes with magnetic iron ore or epidote.

The following localities may be mentioned :

1. Fort Putnam near West-Point, where the well was dug. This is a coarse aggregate of felspar, hornblende, and some quartz.
2. The iron mine on the eastern side of Bare mountain, about four miles southwest of West-Point. Here the sienite is intermixed with titaniferous iron ore.
3. The range of hills west of that on which Fort Putnam is built, about one mile west of West-Point.
4. The base of Butter hill, four miles north of West-Point.

There is another kind of sienite common in the Highlands as loose blocks, but not often seen in place, composed almost entirely of a dark colored felspar, which is sometimes opalescent. It is, however, dissimilar to the labradorite of the mountains of Essex county. It contains a little hornblende, and this is sometimes arranged in a kind of parallelism that gives a partially striped aspect to the rock in one direction. Much of it resembles in some respects the sienite of Mount Eve. It may be seen in blocks from one ton to two hundred tons weight, in almost every part of the Highlands.

3. Gneiss.

This rock is predominant in every part of the Highlands of Rockland and Orange counties. Its modifications have already been described, as well as its stratification, and allusion has been made to some of the transverse upheaves that have changed the dip and line of bearing to a direction nearly perpendicular to the general ones.

This rock has been quarried in many places, but the quarries can scarcely be said to be fairly opened. Many fine locations for quarries exist which have not yet been opened.

Gneiss, and granitic gneiss, have been quarried from the loose blocks at the base of Butter hill and of the Crow's Nest, on the shore. There is a great abundance of durable stone here, which can be easily obtained. It is rather hard to dress, but is beautiful and indestructible.

At West-Point two fine quarries of gneiss have been opened, and worked occasionally for many years. Most of the buildings at West-Point are constructed of stones from these quarries. They are of a beautiful bluish grey color. The quarries are about half a mile north of Fort Putnam.

A quarry has been opened at Block-house point, about half a mile below West-Point, or three-fourths of a mile below Gee's point.

Another quarry may be opened about one-fourth of a mile above Block-house point, on the shore, northeast of the Hospital.

Another quarry has been opened on the shore, about half way between Block-house point and Mrs. Kinsley's. Much of the rock along the shore to near Mrs. Kinsley's landing, may be quarried with advantage.

Cozzens's quarry is one-fourth of a mile below Mrs. Kinsley's.

A quarry has been wrought on the shore, about one-fourth of a mile above Buttermilk falls.

Another extensive one might be opened between that and Buttermilk falls.

Another quarry is at Buttermilk falls.

Mearn's quarry is half a mile below the falls.

Two other quarries are within one mile below the falls.

Faurot's quarries are half a mile and one mile below Consook island. Capt. F. sold twelve hundred tons of stone in New-York in 1838, at one dollar and seventy-five cents per ton.

Another may be opened near Fort Montgomery.

Many other quarries might be opened along the shore at intermediate points, where the stone is of good quality; but much care is necessary in selecting judiciously, since a large portion of the mass of gneiss rock is not of a good quality. Little of the rock from Faurot's quarries to Mearn's quarry is good.

Several fine gneiss quarries might be opened on Wagon's islands, and between these and Caldwell's landing.

4. Mica Slate.

This rock has been described by Prof. Eaton, near Fort Montgomery. It is the rock which, in this report, has been called micaceous gneiss; and like that which has been described on the eastern side of the Hudson, associated with the white limestone, it is pyritous, and usually, where exposed to the weather, has a reddish iron-stained color. It has been observed in several places to contain scales of sulphuret of molybdenum. This has been observed about one mile northwest of Fort Montgomery, two miles northwest of the same place, and at the foot of the Crow's Nest in loose masses. The two former localities showed the rocks in place.

5. Augite Rock.

This rock occurs in very many places in Orange and Rockland counties. It is almost uniformly associated with scapolite and limestone. The augite generally contains sphene and plumbago; and the masses associated with limestone, or where the two rocks come in contact, often exhibit beautiful and terminated crystals. Mica in crystals, often of large size, is frequently associated with augite.

The finest *large* crystallized augite has been obtained,

1. At the locality near Greenwood furnace, Monroe, Orange county.
2. At the mica locality near the Forshee mines in Monroe.
3. At the Two ponds in Monroe.
4. Near the Forest of Dean mine.

Other localities where beds of this rock of small extent are exposed, may be seen,

1. Near the crossing of a small stream by the road-side about two miles from West-Point, on the road to Round pond. It is in place by the road-side, though possibly now covered over, and some large blocks are on the surface. It is associated with white scapolite, which has in some specimens a slight rose tinge, and which is in large opake crystals, and acicular

transparent ones in the cavities of the augite; sphene crystallized, pyritous copper ore and carbonate of copper in small particles; sahlite, coccolite, and diopside.

2. About one-quarter of a mile north of the road leading from West-Point towards Round pond, about half a mile northeast of Mr. Kronkite's or Mrs. Green's, about three and a half miles from West-Point. It is by the side of a wood road, on the side of the mountain, and contains black mica and masses of glassy felspar, and some of fine adularia. Good specimens cannot be obtained without blasting, as most of the loose masses by the road-side have been broken up. It is at an elevation of about one hundred and fifty to two hundred feet above the valley.

3. Another locality is on the mountain southward of Cedar pond in Monroe. I cannot give its location definitely, as the country is perfectly wild. It is not far from the line between Rockland and Orange counties.

4. The locality of the white limestone to the southeast of Duck-cedar pond in Monroe, affords sphene crystallized, and scapolite, and these form with augite an aggregate. Some of the specimens are very rich in crystals of sphene.

5. A great number of localities occur in Monroe, among which may be mentioned several near Greenwood furnace; that near Slaughter pond; Green pond; Island pond; Mumbasha or Mount Basha pond, where the immense sheets of mica are obtained;* O'Neil iron mine; Forshee mine; Clove mine; Rich iron mine; on the road from the Forest of Dean mine, about two miles west or west-southwest; and numerous other places were observed.

In Cornwall, two or three have been mentioned. Augite and coccolite may be found in very numerous places about West-Point, principally on the hill tops or near them, and where a micaceous and pyritous gneiss and hornblende are near. Fort Putnam, and nearly all the crests where redoubts were formerly built, show coccolite and augite imbedded. Several places near the road from West-Point to Fort Montgomery show augite and coccolite, from three to six miles south or southwest of West-Point. Augite, coccolite, and scales of plumbago are found on Mr. Faurot's farm, five miles from West-Point; this is not far from his house. Another locality is about half a mile north; another at an old mine hole one-quarter of a mile south, contains augite, coccolite, sphene, carbonate of lime, hornblende, magnetic oxide of iron, and pyrites.

6. Greenstone.

This rock is very common in Orange and Rockland counties, having the same appearance as that of Westchester and Putnam counties. The varieties are,

1. Compact basaltic greenstone or trap.
2. Granular greenstone.
3. Primitive greenstone.

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* An excavation was made at this place after some unknown substance, probably under the idea that the precious metals existed there, and several wagon loads of large plates of mica were thrown out. I obtained some plates two feet on a side (crystals), as heavy as I could well carry, and loaded my carriage.

The first of these seems to be similar to the trap of the Pallisades; the other is a more crystalline rock, composed principally of hornblende, with some felspar, and, like granite, forms beds, interlaminated masses, veins and irregular intertruded masses among other rocks.

The trap dykes were observed among the rocks of this class in a few places, the principal of which will be enumerated.

1. The trap dykes and interlaminations among the gneiss, granite and white limestone, already described under the white limestone near Duck-cedar pond in Monroe.

2. The dykes at the Two ponds in Monroe.

3. The greenstone in gneiss about three-quarters of a mile southwest of West-Point. It is near the outlet of a small marsh, and a nitch has been cut in the rock to drain it. It scarce shows itself on the surface. Small but perfect crystals of hornblende are sometimes found in masses of this trap. In a quartz vein in the gneiss a few rods farther north, small scales of sulphuret of molybdenum are occasionally found, but specimens can be procured with difficulty. This is not mentioned as a locality for collecting this mineral, but merely to show where a few specimens have been obtained.

4. The dykes through granite on Stony point.

5. Dykes of trap and serpentine traverse the hornblendic rocks west of the granite on Stony point. Prof. Beck, speaking of this place, says, "On the western side of this point, there is a coarsely crystallized hornblende, and with this is associated the mineral usually called kerolite or magnesite. Two parallel dykes of trap pass up the northwestern face of the point, and are distinctly visible by a coating of white magnesian minerals. The rock which has formed the wall of these dykes has disintegrated, and the debris cover the whole of the side-hill. The trap is filled with veins of kerolite of different varieties, some of which closely resemble those of Hoboken and Staten island. There are also other magnesian minerals, and veins of a beautiful silky amianthus are not uncommon."*

The *granular greenstone* is similar to that described in Putnam and Westchester counties, of the texture of a sandstone, composed of grains of hornblende and felspar; the former predominating, and the latter being light colored; and like that rock, it forms interlaminated masses and beds, veins, and irregular intertruded bodies of rock among the gneiss, granite, hornblende, and other rocks of the Highlands. It may be seen in almost every hill and mountain in the Highlands. The Crow's Nest and Butter hill may be referred to as localities; also the hill on which Fort Putnam is located, near West-Point.

The rock called "primitive greenstone," merely because under this name it has been described by various authors, (although the name is inappropriate,) consists of a crystalline aggregate of hornblende and feldspar. It passes into the granular greenstone and trap on the one hand, and into sienite on the other, and may more properly be included among the *hornblendic rocks*. Hornblende predominates and gives character to the rock.

* Fourth Annual Report of the Geology of New-York, p. 91.

Hornblende rock. "Extensive strata of this are found in the Highlands, which are well characterized. The most extensive one observed forms the middle of the southeastern face of the mountain first east of the valley of Long pond, in Warwick. This stratum is, perhaps, twenty-five rods wide. An extensive stratum also runs through the Forest of Dean, along the western margin of the white primitive limestone.* Magnetic iron ore is associated with this stratum in many places

"In addition to what has already been remarked of the foregoing rocks, it should be further stated that the felspar is generally in a larger proportion than the quartz. The color of the quartz is white and bluish, or reddish white; the mica is black, green, or intermediate shades of these colors; and the felspar white, yellow, red and greenish. The hornblende is black, grey or greenish.

"The minerals embraced in the foregoing rocks are numerous and important. First are the ores of iron; all the magnetic oxides are found in them. They also contain adularia, fibrolite, kyanite, manganesian garnet, serpentine, mica, plumbago, sphene, red oxide of titanium, crystallized hornblende, epidote, tremolite, zircon, crystallized augite, tourmaline, coccolite, sahlite."†

7. Quartz Rock.

Quartz forms numerous veins and intruded masses in the Highlands; they may be found in every hill and mountain. It was not seen forming extensive masses, with the exception of one, described by Dr. Horton in Orange county. Describing it, he says, "In the town of Monroe is a bed of quartz. It is two and a half miles southeast of Greenwood furnace. Its northeast end only is visible. At this place it is four rods wide, and rises fifteen feet above the gneiss on each side. It is visible for more than twenty rods, and gradually disappears beneath the surface. The quartz is white and nearly opake, containing in many places pale green coccolite."‡

8. Serpentine Rock.

"Serpentine is found in connection with the iron ore at O'Neil and Forshee mines. A large vein of this substance exists in Warwick, on the east side of Long pond; its breadth is unknown. It is exposed ten feet wide and fifteen feet deep; its color is dark oil-green, approaching black."§ It occurs in numerous localities in small quantities, and is usually associated with the white metamorphic limestones, forming in many places the verd antique marble. Several of the localities have been described among the Metamorphic rocks.

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* This range continues with some interruptions and offsets, north-northeast to near West-Point. Iron ore is associated with it generally.

† Third Annual Geological Report of New-York, 1839, p. 137. ‡ Ibid. p. 137. § Ibid. p. 138.

(C). MISCELLANEOUS REMARKS ON THE HIGHLANDS, AND ON NEW-YORK AND WESTCHESTER COUNTIES.

"The foregoing rocks form the great body of the Highland mountains; they also constitute the rock of many of the short isolated mountains, at a distance from the foot of the Highlands proper, on the northwestern side. Woodcock mountain, in Blooming-grove, is formed of the granitic rock; it is a mile wide at its northeastern termination, and three miles long.

"Round hill, in the same town, is another mountain of the same rock; it resembles very much a half sphere. Pedler hill, in the same town, is still another mountain of granitic rock. Goose-pond, Sugarloaf, Sugarloaf Mate, Brimstone hill and Snake hill, are all primitive elevations in Goshen and Warwick, separated from the Highlands by intervening mountain ridges of transition and secondary rocks.

"Mount Eve and Mount Adam,* in the town of Warwick, near the Walkill, are also primitive mountains, formed of sienitic and gneissoid granite. Pochunk mountain, the most westerly primitive rock east of the Delaware river, has its origin on Pochunk neck, in Warwick, and passes into New-Jersey. Snake hill, in New-Windsor and Newburgh, stands like a primitive island, surrounded completely by transition rocks.

"Four miles north of Newburgh, is a hill composed partly of the granitic rock. This hill is the farthest north and west of any primitive rock east of Shawangunk mountain.

"Half a mile northwest of the village of Washingtonville, in Blooming-grove, on the farm of Mr. Joseph Moffat, is the last and smallest primitive elevation in the county. It scarcely rises above the surface along the western margin of the limestone, and underlies only a few acres in extent.

"All the primitive elevations last mentioned have a line of bearing similar to the great Highland chain, and their dip is the same, and in the same direction, viz. to the southeast.

"The general direction of the Highlands crossing this county is nearly *east and west*, while the line of bearing of the *individual ridges* composing them is about *southwest and northeast*. Thus, a ridge forming about the middle of the range on the Rockland line gradually approaches the western margin of the mountains, until it emerges and forms a part of the northwestern margin of primitive country. Numerous ridges terminate thus in Warwick and Monroe, and do not reäppear north of the great sweep of the Ramapo.

"A very striking feature in these Highland mountains, is the absence of long continuous ridges; of these, there are *none*. They are all broken up into short abrupt hills, many of them one thousand and one thousand two hundred feet high. Another striking feature is, that the southern terminations of these ridges are very generally abrupt, many of them perpendicular naked cliffs, having the appearance of being broken off; while the northern terminations

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* These mountains contain rocks that belong more appropriately to granitic and intrusive rocks, and their age seems to be of the age of the metamorphic white limestone of Warwick.

are gradual, and slope gently to the surface, and disappear. Butter hill and Woodcock mountains are exceptions to the above appearances; but even Butter hill, steep as it is, has not the ragged broken appearance which many southern terminations exhibit."*

Gneiss is the prevailing rock of the Highlands. It passes into hornblendic gneiss and hornblende rock on one side, and into micaceous gneiss and mica slate on the other. The latter is very rare, while the micaceous gneiss is more common, and the hornblendic gneiss is one of the most common rocks.

Granite is very abundant, both in beds and veins. That in beds is often twenty to forty feet thick, of a coarse grain with a base of red felspar, and often contains adularia and epidote. Examples may be seen near the landing at West-Point, and in that vicinity. The granite of the caps of the hills and mountains is frequently of a finer grain, sometimes suitable for a building stone. The granite in veins is generally of a still finer grain. There seems to be little regularity in the direction of the veins, but perhaps a majority of them intersect the strata nearly at right angles, *parallel to the direction of one set of the joints* that have been described while treating of the rocks of the New-York System.

The dip of the rocks is very variable. In many places the strata are nearly or quite vertical, in others they are nearly horizontal, and they vary indefinitely between these limits, and are in some places contorted, so as in short distances to show every possible amount and direction of dip; but notwithstanding these great variations, the *prevailing dip is to the E.S.E. from* 30° *to* 70°.

The general line of bearing of the strata in the Highlands and Westchester and New-York counties is north-northeast and south-southwest, and this direction approximates to the direction of the hills and mountains; but these latter, as has been before stated, are not uninterruptedly continuous in any place more than a few miles.

There are many localities where the line of bearing has been mentioned as transverse to the general direction, ranging between west and northwest, with a dip to the north, north-northeast and northeast. The facts connected with the transverse lines of bearing and of disturbance and faults will be mentioned in another place, when treating of axes of elevation and disturbance.

Local Details.

These are selected from a great number of observations, as having some interest; some in an economical point of view; some for those who will examine the localities; some in elucidating the particular local geology; and some as having a bearing on various points of physical geology, which may be useful to those who may have time and opportunity to trace out the lines of disturbance with which they are connected.

The subjoined table exhibits the kinds of rocks seen on the shore from Peekskill to Anthony's Nose point, and thence up the Hudson to the point northwest of the "Old silver mine," along

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* Annual Geological Report of New-York, 1839, p. 188, 139.

the left bank of the Hudson. The distances were estimated by the eye, not measured, and of course are not accurate, and along the base of the mountain are much underrated. The rocks are illustrated in position as far as Roya hook, on Pl. 14, fig. 4.

No. of course.	Remarks on the direction from place to place, with the strike, dip, and nature of the rocks, etc.	Distances in yards.
1	From Peekskill upper dock, N. 50° W. to point	300
	Granitic gneiss, grey. Fine building stone.	
2	N. 40° W. Dip N. 50° E. about 50°	150
3	N. 20° E. Same rock	50
	Granular quartz finely stratified. Dip S. 60° E. about 60°. This rock would make a fine flagging stone.	
4	N. 40° W. across the mouth of Peekskill creek	300
5	S. 80° W. to Roya hook	800
	Quaternary formation along the shore a part of the way, and salt marsh northeast of the hook.	
6	N. 70° W. to Gen. Van Cortlandt's gneiss quarry;	250
7	and thence on the same course to quarry point	200
8	N. 45° W. to the cove	200
	The ground is but little elevated, but contains fine granite, some of which has been quarried. Island south one hundred yards off shore.	
9	S. 60° W. to a point on which hornblendic gneiss prevails	150
	The strata are nearly vertical, and a marsh is on each side of the point in the re-enterings of the shore.	
10	N. 40° W. to the Second granite point	150
	A pine tree stands conspicuous on the point.	
11	North to a small marsh	150
	Granite and gneiss forms the shore to the marsh, and quarries might be opened here.	
12	N. 30° W. to the west end of the marsh	120
13	N. 70° W. to the Third granite and gneiss point	50
14	N. 40° W.	200
	Gneiss, hornblendic gneiss, and compact felspathic gneiss. Strata vertical.	
15	N. 15° W.	300
	Granite, gneiss, and hornblendic gneiss. Dip vertical and variable. Range or strike in some places N.N.E., and others N.N.W., and dip 30° E.N.E.	
16	N. 40° W. in a direction towards Mrs. Pell's house, from the foot of the wood-slide	500
	Granite and hornblendic gneiss.	
17	N. 25° W. to point east of Anthony's Nose point	400
	This point is in the line that, if prolonged, would strike Fort Montgomery lower landing.	
18	N. 20° W. to Anthony's Nose point	300
	Line prolonged would strike Fort Montgomery hill; and Mrs. Pell's house bears N. 70° W. about half a mile. Rock compact, and may perhaps be called eurite at the point.	

No. of course.	Remarks on the direction from place to place, with the strike, dip, and nature of the rocks, etc.	Distances in yards.
19	N. 10° E. from Anthony's Nose point along the rocky shore;	150
20	and thence along the same course, skirting the salt marsh to a rocky island	600
21	N. 40° E. along the shore of the island	400
	The rock here is hornblendic gneiss, granite and gneiss. The line produced would strike Sugarloaf mountain. The rock of this island, where seen, was not suitable for a quarry stone. The marsh in rear of this island is about two hundred to three hundred yards wide.	
22	N. 45° E. to another rocky island;	100
	and thence along the shore of this island	150
23	N. 50° E. to Serpentine point, along the edge of the marsh	300
	The marsh extends from the rear of this point, (on which serpentine limestone and verd antique are found,) in the rear of the islands mentioned, to near Anthony's Nose point.	
24	N. 15° E. along the shore	109
	This line prolonged would strike the camp ground on the plain at West-Point.	
25	N. 35° E.	100
26	N. 45° E. The strike here is N. 50° E., and dip 70° N.W.	300
27	N. 55° E. to forty feet west of an old landing	150
	The rocks here are micaceous pyritous gneiss, and impure verd antique.	
28	N. 70° E. at the north end of the neck on which the Old silver mine is located	80
	The rocks here are felspathic gneiss, micaceous pyritous gneiss, white limestone containing imperfectly characterized brucite, etc. This neck, and the shore for two miles north-northeast, is very interesting to the geologist.	

From Fort Montgomery, the shore of the Hudson and of the salt marsh trends nearly south about two and a half miles. At three-quarters of a mile south of Fort Montgomery on the shore, the north end of Wagon's first island bears S. 40° E. about half a mile. This island is about half a mile wide from north to south. The salt marsh extends from the southwest end to the main land, and the flats extend from the northwest point in a curved direction towards Mrs. Pell's house. In the cliff below Mrs. Pell's, a bed of granite seventy-five to one hundred feet thick lies between strata of gneiss, the strike of which is easterly and westerly, and which dip to the northward about forty-five degrees.

No.	Remarks on the direction, etc.	Yards.
1	From three-quarters of a mile south of Fort Montgomery to north point of Wagon's island, about 900 yards. Course S. 40° E.	900
2	To the second point of Wagon's island, S. 30° E.	400
3	To the third point of Wagon's island, S. 25° E.	400
	There is a bed of good grey granite on the shore on this course.	
4	S. 20° E. into a little bay	100
5	S. 60° E. to the point on the east end of the island	150
	Granite was observed along both the last courses.	

No.	Remarks on the direction, etc.	Yards.
6	South	100
7	S. 30° W. to south point of second Wagon's island	150
	The marsh extends between these islands, and southwards to the main land half to three-quarters of a mile.	
	The flats extend from the south shore about S. 20° E. to the base of the Dunderberg mountain, and are covered with water except at extremely low tides	1500
8	S. 40° E. Granite and gneiss	200
9	S. 40° E. (Granite on this course)	300
10	South. Granite and gneiss to the *point* of Dunderberg	100
11	S. 10° W. Flats and beach (narrow) on shore.	
12	S. 25° W. to Ward's wharf at Caldwell's landing	250
	The quaternary hills here line the shore, and form a bank or terrace about seventy to one hundred and twenty feet high, between the shore and the Dunderberg mountain.	

Stony point, two or two and a half miles below Caldwell's landing on the right bank of the Hudson, a place of some celebrity in the history of our country, has already been spoken of as having fine granite, which is traversed by dykes of greenstone, and hornblendic rocks also traversed by trappean dykes and veins. A considerable portion of this peninsula, which is properly an island, connected with the main land by an alluvial salt marsh, is composed of hornblendic gneiss like that on the eastern shore of the Hudson, a mile and a half below Verplanck's point. As we progress westward from the point, it becomes the sienitic rock, and finally the pure hornblende rock in some places. The similar rocks on the eastern side of the Hudson bear about N. 70° E. of these. The hornblende rock on a hill on the north shore of Stony point peninsula, crumbles into a black hornblende sand, and many slight excavations have been made with the hope of finding iron ore in this hill. The rock is very heavy and black, and the color and weight of the rock have induced the expectation. Coal has also been expected here by those who have been misled by the black color of the rock.

Many interesting magnesian minerals occur here, connected with the dykes in the hornblende, and the seams of the rock for several rods from the dykes. They are very similar to those of the serpentine rocks of Staten island and of New-Rochelle. The other rocks of this vicinity have already been described under the Taconic system, the Metamorphic rocks, Red-sandstone and Trappean divisions. This vicinity is one of the most interesting and instructive localities for the student of geology.

The Colaberg and Buckaberg mountains lie to the southwest of the Dunderberg; they are composed of gneiss and granitic rocks. Near the turnpike gate on the top of the mountain, the strata are vertical, and more or less streaked with hornblende. Farther west, they are sometimes vertical, and sometimes dip easterly seventy to eighty-five degrees.

On the western declivity of the eastern main range of the mountains, in descending into Kyle's valley (through which Stony brook flows south-southwest into the Ramapo at Slote-burgh), the stratification was observed for a short distance to be *transverse* to the general direction (nearly east and west); but in a few rods on either side, the regular direction of N. 30° E. was resumed.

Gneiss with beds of granite, frequently streaked with hornblende or with grains of magnetic oxide of iron, was seen in crossing the mountains farther west, to M'Farlane's iron-works in the valley of the Ramapo.

Gneiss is the prevailing rock in this valley south to Sloteburgh, and thence southeast to where the Ramapo leaves the Highlands. In many places it is hornblendic, and passes into hornblende rock. Beds and veins of granite are not rare. A fine granite for building occurs half a mile west of the Ramapo works, up the valley, and another about the same distance down the creek. These must be near the New-York and Erie railroad, and may perhaps be made available at some time, as the transport would be easy. The dip of the rocks is generally at a high angle to the southeast or east-southeast.

A bed of granite was observed on the hills about one-half to three-quarters of a mile from Capt. Faurot's, four or five miles southwest of West-Point.

Gneiss rocks are frequently seen in place along the road from Capt. Faurot's to West-Point, and along almost the whole of the shore. They generally dip at a high angle to the east-southeast, and contain many beds of granite. Scarce a single quarry can be examined, or any considerable surface of the naked rock, without finding numerous granite veins. Many of them are very tortuous. Quartz veins are also not uncommon. Wherever cliffs are exposed on the shore, and particularly between Mearn's landing and Buttermilk falls, and also between the latter place and Mrs. Kinsley's, and near Block-house point, the *joints* of these rocks are beautifully exposed to view. The rocks are divided into large blocks by these joints, of from a few tons to many hundreds and thousands of tons weight. The direction of the principal joints is about N. 60° to 70° W. They may be seen almost every where in the Highlands where cliffs are exposed. Along the shore, the cliffs frequently present a serrated outline to the water line, in consequence of the lateral heaves or faults along these joints, presenting mural escarpments on the southern and eastern sides.

The rocks from West-Point to the Forest of Dean iron mines are gneiss, frequently hornblendic, with beds of granite, hornblende, augite and limestone. Granite beds are numerous and extensive on the crests of the hills and mountains west, northwest and north of Kronkite's and of Round pond.

A bed of limestone about two and a half miles west of West-Point, has not been mentioned. It is the grey siliceous limestone, apparently like the Calciferous rock of the Champlain division, slightly modified. This locality I have not seen, and the rock possibly may not be in place. I have only seen specimens, and been told that it was quarried and burnt into lime. The remains of two or three limekilns are within a short distance, near the roadside.

On the road from the Forest of Dean mine to Fort Montgomery, a ridge of felspathic rock was seen, which from its aspect might be called granite. It would make a good building stone. It forms a high peak and ridge, about two miles west of Fort Montgomery, and it seems also to form the west side of Bear mountain to the south, and to extend also to the northeast to the top of Bare hill or mountain.

The *Primary rocks in Dutchess county* occupy Pawlings, the eastern part of Beekman, the southeastern and southern part of Fishkill, the eastern part of Dover, and a small part of Pineplains and Stanford. The rocks in the southeastern parts of the county are precisely like those described as the Highlands of Putnam county, and are parts of the same mountains.

Granular quartz rock was observed on the eastern side of the Dover valley in Dover, adjacent to the gneiss rocks; but this and the contiguous white dolomitic limestone belongs to the metamorphic rocks, and have been described.

The mass of Primary rocks in Pineplains and Stanford, is called Mount Stessing. Its highest peak is probably elevated nearly a thousand feet above the level of the lake on its eastern side. It is composed of gneiss and hornblendic gneiss with some granite, all of which are like the rocks of the Highlands. The strata range N. 15° to 20° E., and dip from seventy to ninety degrees to the westward. The mountain is entirely isolated, like an island, surrounded entirely by the quaternary and the rocks of the Champlain division. The Potsdam sandstone rests on the primary at the southwestern end of the mountain, and this is covered by the grey limestones and the slates of the Champlain division. The slates on the western side of the mountain are broken and crumpled up in the greatest confusion.

Blackwell's island, and the contiguous part of the island of New-York, are gneiss, often traversed by veins of granite. The gneiss dips to the eastward at a high angle, and the strike is about N. 20° to 30° E.

The little reefs and islands near Hurlgate are also rocks of the same character, containing more or less hornblende.

Barn island, Riker's island, Little Barn island, the Brothers, and some others have a nucleus of the same rocks, mostly covered by the drift and quaternary depositions.

The small islands near New-Rochelle and in that vicinity, have a basis of rocks of gneiss, both fissile and thick-bedded, and sometimes hornblendic like those at Hurlgate. The strata are nearly vertical, and the strike is about north-northeast and south-southwest.

On the post road from New-York to Albany, limestone is quarried for a flagging stone, near Livingston's village in Westchester county. Chlorite and nacrite are the substances that make it fissile.

Northeast from Singsing, the limestone becomes micaceous, and so modified as not to be easily recognized. Much of it is very fissile, and so much intermixed with mica and felspar, that it might with propriety be called a calcareous mica slate; but much of it contains so little carbonate of lime as to be distinguished with difficulty. About three miles northeast from Singsing, the gneissoid mica slate is succeeded by gneiss and hornblendic gneiss.

Limestone was seen in place in two localities, on the road from Pines bridge to Peekskill. The limestone on the hill southeast of Peekskill is much bent and contorted, and is variegated. When broken, it presents bent lines of grey, black and white, like an agate.

After crossing the limestone and talcose slate of Peekskill creek, the traveller comes suddenly upon the granitic and gneissoid rocks of the Highlands, and he observes augite to abound in many places in these rocks, and in some it enters as a constituent. The

rocks continue nearly the same to West-Point, and dip east-southeast sixty to ninety degrees.

On the turnpike from Coldspring to Carmel, the rocks are gneiss and micaceous gneiss, hornblendic gneiss with beds and veins of granite, greenstone and hornblende rock. The gneiss on the eastern declivity of the mountain, for some distance from the crest, is hornblendic, and the dip is to the eastward where it is not vertical.

The heavy swell of land, composed in part of talcy slate, east of the limestone that was seen near Bonnell's forge, is bounded on the east by Horton's pond and its outlet. Gneiss was frequently seen in place after passing into the valley of the pond; and on the eastern side of its outlet, the rock had much the aspect and composition of some of the felspathic and sienitic rocks southeast of Peekskill, though they had more of a granitic aspect.

The rocks at *Coldspring landing* are gneiss, hornblendic gneiss, and granite. The strata have a north-northeast and south-southwest direction, and the dip is vertical at the south point.

Constitution island, between Coldspring and West-Point, is composed of gneiss, hornblendic gneiss, granite and sienite. The stratification is much confused, and some of the rocks have a strike transverse to the usual direction, viz. northwest and southeast. This appears to be on the transverse line of disturbance that has been observed farther east-southeast in several places, and on the west-northwest near the cascade, and on the mountain farther west. Granite and sienite form the Target rock, a high cliff on the southwest side of the island, and granite forms some of the points farther north. Hornblendic rocks (gneissoid) form the shore a little north of the Target rock; they lie in strata dipping at high angles to the northeast, and some are nearly vertical.

The rock at the *Floating dock at the steamboat landing* at *West-Point* is granite, as also Gee's Point. Granite is seen in abundance on the sloping ridges, leading from the plain of West-Point north towards the Hudson, between Kosciuszko's monument and the Cadet's monument; these are distant from each other 4161½ feet.*

Flat rock at Mr. Arden's boat landing, two and a half miles south of West-Point, is granite.

The geological explorer can scarcely fail of finding numerous localities of granite, gneiss, sienite, greenstone, hornblende rock, augite, limestone, etc. in exploring the shores of the Hudson through the Highlands.

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* The maps of the Highlands are extremely inaccurate, so that they are of little aid in fixing localities. With a view of noting down all the facts connected with the complicated geology of the Highlands, I began a triangulation of the country for several miles around West-Point, and prosecuted it when not otherwise engaged in 1833 and 1834. Some progress had been made in the construction of a topographical map of that region, based on triangulation, as accurate as I could effect by a common theodolite, and measurement of a base line with the common measuring tape. The map, as far as constructed, has been lost; but some of the notes and results of the calculation of the triangles remain, and they are subjoined, as they may aid some one in the construction of a map. The original base line or line of reference is a prolongation of the north end of the North Barrack at West-Point; its western extremity being 414½ feet westwardly from the northwest corner of that building, on the line mentioned; and the eastern extremity is on the edge of the plain on the above line eastwardly from the barrack. The whole length of the base line is 1026½ feet.

(D). PRIMARY ROCKS OF SARATOGA AND WASHINGTON COUNTIES.

The primary rocks occupy about two-fifths of Saratoga and one-fifth of Washington counties. Lines drawn a little south of west to the west part of the county, and a little east of north to the Hudson, from Saratoga springs, would include all, or nearly all, of these rocks

TABLE EXHIBITING A SURVEY OF THE COUNTRY AROUND WEST-POINT.

STATIONS.	Angle.	Course.	Distance.
	o '		Feet.
STATION A. *West end of the base line.*			
To east end of the Base line	000 00	.....	1026½ measured.
Kosciuszko's monument	328 30	.....	1630½ calculated.
Wood's ditto	246 15		
Cadet's ditto	232 55	.....	3660½
Flag staff	240 50	.....	647
the Hotel	293 10	.....	1358
the Crow's Nest, highest point of the mountain	220 40	.....	9427
the Old Beacon, highest point	271 52	.....	17737
Ditto, summit northeast of the last	279 56		
Ditto, summit on the Breakneck mountain range	285 40		
Bull hill	264 07		
Breakneck, first peak	258 14		
Dittto, second peak	260 30		
STATION B. (N.) *East end of base line.*			
To the west end of the Base line	000 00	.....	1026½
the Flag staff on the plain at West-Point	22 50	.....	1456
the Cadet's monument	42 05	.....	4357
the Crow's Nest summit	36 55	.....	10228
Kosciuszko's monument	114 10	.....	951
Old Beacon summit	88 33	.....	17733
the Hotel about perpendicular to the front	68 28	.....	1342
the summit northeast of Old Beacon summit	97 16	.....	21733
the ammunition house of the Battery	305 12	.....	456
the high peak on the Breakneck mountain range	104 39	.....	35704
Station D on Fort Putnam	343 10	.....	2707
Bull hill	81 33	.....	22373
Pyrophylite point opposite Buttermilk falls	274 45		
Beakneck west summit	75 42	.....	23113
Granite point, above the last on the shore	270 00		
Mine point, above the last on the shore	259 10		
Cooper's shop, across the cove from Mine point	253 25		
G. Garrison's wharf	241 35		
Southeast corner of the Hospital garden fence	290 40		
East point of the rocky peninsula, on the flats	279 42		
West point of the same	281 00		
STATION C. (M.) *On the base line.*			
To the east end of the Base line	000 00	.....	345½
Kosciuszko's monument	130 16	.....	1137
the ammunition house of the Battery	257 30	.....	381·7
the Redoubt east of Fort Putnam	318 00		
STATION B. *At Wood's monument.*			
To Kosciuszko's monument	000 00	.....	1821
the Hotel	337 45		
the Highland school (stone house)	329 36		
the peak of the hill beyond the Highland school	326 40		

in Saratoga county; but the natural boundaries of these rocks form very irregular, curved, and serrated lines, in consequence of the chains of hills of the Primary rocks stretching to the south, and of the valleys between them in which newer rocks enter, like water on an irregular line of coast.

TABLE CONTINUED.

STATIONS.	Angle.	Course.	Distance.
Station B *continued.*			
To the red house and point of rocks next the old fort on Constitution island	° ' 318 50		Feet.
the second rocky point near the second red house	314 10		
the high ledge beyond on the first point and second red house	308 10		
the Chain battery and battery north of second red house	300 00		
the mountain peak northeast of the second red house	308 25		
the Blast furnace (high furnace) Kemble's	293 05		
the Baptist church	285 00		
the Lower target on the sand-bank	284 45		
the rocky point above the Lower target	278 10		
the Broken target rock (sienite cliff)	276 45		
the point above the Broken target	266 30		
the second point above the Broken target	267 10		
the end of the dock at Coldspring landing	264 45		
the end of the dock above	264 40	.....	11994
the peninsular point above (Quarry point)	256 08		
Breakneck point on the shore	253 35		
the point above, on the shore	253 00		
the east point of Polepel's island	251 28		
the west point of Polepel's island	249 35		
the point of the Crow's Nest on the shore	248 30		
the point above the Upper target west shore	245 30		
the Upper target	245 00		
the conglomerate and pebble beds above Washington's valley	236 00		
the point below on the shore	238 00		
the Cadet's monument	228 43	.....	2728½
the north peak of the hill west of Fort Putnam	175 00		
the second peak of the same hill	157 30		
the northeast summit of the Crow's Nest	235 00		
the highest peak of the same	218 30		
the ravine southwest of the same	206 50		
STATION C. *Cadet's monument.*			
To Kosciuszko's monument	000 00	.....	4161½
Wood's ditto	19 12	.....	2728½
the Highland school landing	331 25		
the point of marsh west of the above	330 30		
the head of the cove between	327 50		
the mouth of the bayou (outlet of the marsh)	323 00		
the lowest point of rock on the shore next the fort on Constitution island	326 10		
the second point of rock near the second red house on Constitution island	327 00		
the third point a little below the Chain battery	325 35		
the Chain battery	321 00		
the target in the sand-bank opposite the dock	313 35		
the point of rocks above the target	313 00		
the broken Target rock (high cliff of sienite)	301 50		
the point above	292 00		
the point in the cove	387 00		
the point above (above the Bomb target)	271 00		
the Bomb target in the cove	281 00		
the upper or northwest point of Constitution island, reddish coarse granite rock	275 00		

The Primary rocks enter Washington county from Warren county, near the southwest corner of the town of Fort-Ann, and range north-northeast between Lakes Horicon or George and Champlain. The southern boundary of this formation in Washington county is a very irregular line, from the same cause as that of Saratoga county; but its trend is about east,

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TABLE CONTINUED.

STATIONS.	Angle.	Course.	Distance.
Station C continued.	o '		Feet.
To Mr. Kemble's house and to the west end of the marsh	276 00		
the Foundry (large stack)	280 40		
the road in sight to Phillips's ore bed	281 30		
the Foundry wharf	273 45		
the Foundry second wharf	261 30		
the Church on the point at Coldspring	256 30		
the point below Coldspring vertical strata	255 20		
the end of the wharf at Coldspring	250 15		
the end of the wharf above Coldspring	247 00		
the rocky peninsula point above (Quarry point)	234 00		
Breakneck point on the shore	227 50	.....	15873
the point above	227 00		
the Upper point	226 30		
Breakneck, western summit	234 30	.....	17147
Ditto, second summit	236 30		
Bull hill summit	242 00		
the Old Beacon summit	251 30		
the summit northeast of Old Beacon	259 30		
the summit northeast of the Foundry	289 00		
the summit northeast of the Highland school	310 00		
the Highland school	318 00		
Station No. 3 on the mountain back of Mahony's tavern	127 05		
STATION D. *Fort Putnam on the southwest side, between two high points of the broken wall.*			
To Kosciuszko's monument	000 00	.....	3405½
the Flag staff	344 00		
the Hotel	346 00		
the east end of the Base line.	.....	.....	2707
Battery on Constitution island north of second red house, and the Chain battery, are in line.			
To Gouverneur's point	22 00		
Gouverneur's wharf point	29 45		
Garrison's wharf point	55 00		
Coopers' shop near Mine point	74 00		
Pyrophyllite point	107 30		
Cotton rock	111 00		
Peninsular point (peninsula on which the "old silver mine" is located)	116 45		
the Flour mills at Buttermilk falls and the hill between	114 00		
the second summit of the Dunderberg mountain	130 00		
Anthony's Nose mountain (highest point)	125 30		
the southern summit of the Sugarloaf mountain	97 00	.....	11100
the northern summit of the same	92 00	.....	10072
the summit of hill east of Mr. Arden's, and north of Sugarloaf mountain	73 00	.....	9114
the summit of the hill southeast of the Episcopal church	58 00	.....	11542
the summit of Battery hill, east of the Phillips manor house, (Mr. Governeur's)	43 30		
The laumonite and stilbite locality is at the north base of this hill.			
To the eastern summit of the Crow's Nest	276 00		
the highest summit of the same	260 30		
the ravine southwest of the same	250 25		
the summit west of the above ravine	244 45		

along the valley of the west branch of Wood creek to Fort-Ann. The eastern boundary is a similar irregular line, but not so much serrated, and the trend is to the north-northeast from Fort-Ann to Whitehall.

The two areas above described in Saratoga and Washington counties, include all the granitic rocks in the district under examination. By far the largest portion of this area is in a

TABLE CONTINUED.

STATIONS.	Angle.	Course.	Distance.
	o '		
Station D *continued.*			
To the second summit west of the same ravine	238 40		Feet.
the north peak of hill west of Fort Putnam	253 30		
the battery on the same ridge	212 30		
the peak between the Battery and North peak	237 30		
the peak south of Fort Putnam and west of Mrs. Kinsley's (Mine mountain)	142 00		
STATION E. *Ammunition house.*			
To Kosciuszko's monument	000 00	.....	1401
Station D on Fort Putnam	232 15		
Gouverneur's point (tangent to it)	60 00		
Gouverneur's wharf point	76 00		
Battery hill summit east of the Phillips manor house	85 00	.....	7320
the Episcopal church	99 15	.....	4476
Garrison's wharf	117 00		
Mine point	138 30		
STATION F. *Gouverneur's wharf point.*			
To Kosciuszko's monument	000 00		
Station E (ammunition house)	326 00		
Station D (in Fort Putnam)	313 45		
the centre of the Hospital	305 00		
the house below at the south gate of the Post	296 30		
Block-house point	271 50		
Bare-rock hill summit	276 00		
Mrs. Kinsley's house	266 15		
the battery on hill west of Fort Putnam, and to Fort Putnam, both in line.			
Bull hill summit, and second red house on Constitution island in line	25 00		
Baptist church	38 45		
Peak northeast of Old Beacon, and the sandbank near the Foundery	43 20		
STATION G. *Garrison's wharf.*			
To Kosciuszko's monument	000 00		
Station E (ammunition house)	342 40		
Mrs. Kinsley's	260 00		
Bare-rock summit	259 10		
Flour mills at Buttermilk falls	234 30		
Mine point	213 10		
Wharf near the Cooper's shop	203 00		
Point above the Cooper's shop	195 00		
Anthony's Nose mountain	215 30		
Bear mountain summit	230 20		
STATION H. *At Granite point.*			
To Kosciuszko's monument	000 00		
Flour mills at Buttermilk falls	220 30		
Bare-rock hill summit	238 12		
Pyrophyllite point opposite Buttermilk falls	171 00		

state of nature, covered with timber, and by many considered of little value when the pine lumber is cut off. The soil, though rough, stony, and generally mountain land, produces fair crops when cultivated. Its aspect is forbidding to the cultivator, and is better adapted for grazing than cultivation. The natural soil compares well with the mountain lands of Vermont, Massachusetts and Connecticut; but as long as there are such quantities of better land for cultivation at a cheap rate, near our principal markets, these will scarcely be occupied,

TABLE CONTINUED.

STATIONS.	Angle.	Course.	Distance.
	o '		
STATION I. *A little south of Mearn's point.*			
To Kosciuszko's monument	000 00		
Pyrophyllite point	320 00		
Augite point	16 30		
Sugarloaf mountain peak	23 00		
Flour mill, and to the rocky peninsula on the flats east of West-Point	354 30		
Fort Putnam	351 20		
Bare Rock summit	325 00		
Faurot's wharf N. 60° W.			
STATION K. *On Wagon's island.*			
To Anthony's Nose peak	000 00	N. 5° E.	
Bear mountain peak	289 00		
Fort Montgomery lower landing	338 00		
Ditto	339 00		
Ditto, upper landing, and Anthony's point in line	345 00		
Point towards Peekskill, and to upper wharf	121 30		
Peekskill principal landing	125 45		
Dunderberg point on the shore	142 00		
Island one hundred yards off shore near the base of Anthony's Nose mountain referred to in the notes of courses on that shore, vide p. 551	118 00		
the east peak of the Dunderberg mountain	162 30		
STATION L. *Fort Montgomery upper landing.*			
To Anthony's Nose high peak	000 00	S. 32° E.	
Station K, and to Anthony's Nose point	25 50		
the northwest point of Wagon's island, south of Anthony's Nose	31 30		
the southwest point of same place	42 00		
the second point of the Dunderberg	53 15		
Station I. on Mearn's point,	277 00		
Two peaks of the Sugarloaf mountain	265 45		
Point below Station I. (Serpentine point) westwardly from the "Old silver mine"	284 15		
Rocks below the salt marsh	287 00		
Upper point of next rocks (island on edge of the marsh)	294 30		
Lower point of the same	328 00		
Bear mountain summit	96 30		
Ditto, eastern summit	82 00		
STATION O. *Southeast corner of hospital garden fence.*			
To Station C. (M.) at east end of the base line	000 00		
Kosciuszko's monument	1 20		
Gouverneur's point	46 40		
Gouverneur's wharf point	54 25		
Gouverneur's house (Phillips manor house)	61 30		
Battery on the hill east of the house	81 40		
North peak of the hill north of the Sugarloaf mountain	119 55		
North peak of the same	142 20		

unless the iron business should be more extensively carried on, and for which there are great natural advantages.

The rocks of this region of country are mostly gneiss and granite. The gneissoid rock has all the characters of gneiss, except that the mica is very generally absent, and the same remark applies to the granitic aggregate. Garnets, hornblende or magnetic oxide of iron, frequently seem to form constituent parts of the rocks. The gneiss and granite are grey and reddish, according to the color of the felspar. Hornblende is so abundant in some of the laminated rocks, as to make the name of hornblendic gneiss appropriate.

TABLE CONTINUED.

STATIONS.	Angle.	Course.	Distance
	o '		Feet.
STATION N. *At east end of the base line.*			
To Kosciuszko's monument	000 00	.....	951
Base line	245 50		
Hotel	314 30		
Cadets' monument	288 00	.....	4357
Fort Putnam	239 00		
STATION M. (o.) *On the public wharf.*			
To the hotel, perpendicular to its front	000 00		
the flagstaff	47 26		
the Cadets' monument	135 00		
the battery on the hill west of Fort Putnam	82 30		
the peak north of the above battery	90 20		
the north peak north of the above peak	93 00		
First rocky point	88 00		
Second ditto	100 30		
Third ditto	115 00		
Fourth ditto	164 40		
First target on the right bank of Hudson river	120 30		
Second target on the same bank	161 45		
Point below the wharf and end of lower dock	275 00		
High cliff back of Coldsprings on Bull hill in line with Gouverneur's point, and the fort near the red house on Constitution island.			
STATION P. *On a prolongation of the base line eastwardly on a high hill-side.*			
To the north end of the north barrack at West-Point;	000 00		
and to base line east end on the plain of West-Point	.....	.....	12969
Fort Putnam	356 48		
Kosciuszko's monument	3 43		
Hotel	5 16		
Cadets' monument	10 13		
East point of Anthony's Nose?	291 20		
Bear mountain	313 50		
Round-peak mountain, northwest of Fort Montgomery	321 00		
Bare mountain or Bare-rock mountain	337 35		
the battery on the hill west of Mrs. Kinsley's	343 20		
the summit west of Bare-rock mountain	341 35		
Kronchites ?	350 00		
the peak west of the ravine	10 16		
the ravine southwest of the Crow's Nest	12 36		
the Crow's Nest, highest point	16 07		
the southeast peak of the Crow's Nest	19 00		
the northeast peak of the same	22 30		
Butter hill peak	32 06		
Peak southwest of the above	26 43		
Battery on the hill east of Gouverneur's	330 20		
Hill south of the battery, and to Bear mountain a little west of its summit	315 35		

In some places, particularly the upper portions of the mass, in some localities along Lake Champlain, the gneiss seems to be a metamorphic rock, that was once the Potsdam sandstone. In Galway, the same rock (it is believed) is a quartz rock, sometimes resembling granular quartz rock. These metamorphic rocks are every where in the vicinity of undoubted intrusive rocks.

TABLE CONTINUED.

STATIONS.	Angle.	Course.	Distance.
STATION Q. *On the crown of the hill about 750 yards N. 170° E. of* P., *on a ridge of gneiss ranging N. 44° E.; dip vertical.* NOTE. The distance between P. and Q. is not to be used as a base line in any calculations, as its length was not ascertained accurately either by calculation or measurement. It was taken because it offered facilities for seeing several places not visible from the Station P. The bearing by compass also may not be accurate, as the needle did not traverse freely.	° ′		
To signal on Fort Putnam	000 00		
Kosciuszko's monument	4 31		
Cadets' monument	13 00		
Second northeast peak of the Crow's Nest	33 00		
Butter hill peak	38 30		
Peak southwest of above	33 00		
Cornwall landing behind the slope of Bull hill	43 00		
Bull hill summit	49 45		
High cliff back of Coldspring	47 00		
Old Beacon	57 50		
A high peak one and a half or two miles northeast	82 35		
New Beacon?	97 09		
Mountain peak southeast of the road to Phillips's ore bed	103 00		
a branch peak of the above, round backed and cultivated	93 00		
Anthony's Nose	315 30		
West peak of the Dunderberg	312 50		
High greenstone peak (High Torn?)	294 30		
High greenstone peak, westward of the above (Little Torn)	299 30		
Sugarloaf mountain	320 50		
A high ridge extends from northeast to southwest about a mile east of this station southwest, eastward of the Sugarloaf mountain; its highest peak is nearly opposite the peninsular point. To this high peak	307 30		
STATION R. *At the Upper target, west side of river.*			
To Kosciuszko's monument and the northwest corner of the public dock	000 00		
Wood's monument	15 00		
Mouth of the brook	48 00		
Point below the above	22 30		
Mouth of cascade	17 20		
Point below the Cadets' monument	18 30		
Gee's point	353 15		
Gouverneur's point	352 00		
Northwest rocky point of Constitution island	318 30		
Bottom of cove east of above point	304 30		
North point of Constitution island	292 00		
Sand-bank near the foundry	285 30		
Foundry wharf	281 30		
the cliff north of Coldspring	241 00		
Quarry point above Coldspring and the point above this station in line	222 30		
Buoy below Coldspring near the "Brothers"	295 00		
South Brother (rock emerges only at very low tide)	294 00		
North Brother (similar emergence)	293 20		

Granite is a very abundant rock in the region of country described. On the eastern shore of Lake Horicon or George, it is one of the most common rocks, and may be seen on almost any part of its coast. It is grey and red, the color depending on that of the felspar, and it is generally rather fine grained. On the canal, half to one mile south of Comstock's landing, a mass of granite rock with red felspar may be seen; it is here coarse grained.

TABLE CONTINUED.

STATIONS.	Angle.	Course.	Distance.
	o '		
STATION S. *On the Crow's Nest, highest summit.*			
To Old Beacon summit and signal	000 00		
Summit near the above east-northeast	330 00		
Summit northeast of Hustis's high mountain	3 30		
a high peak on Breakneck mountain range	353 25		
a high peak, (New Beacon ?)	347 10		
a high peak	351 15		
the mountain south of the road from Coldspring to Phillips's ore bed	24 20		
the peak of Deadwood hill (deadened by fire)	24 20		
the round backed cultivated hill south of the preceding	30 00		
Butter hill, eastern summit	305 00		
Ditto, western summit	288 30		
Bare-rock mountain, eastern summit	145 00		
Ditto, highest peak	148 30		
Anthony's Nose mountain	141 50		
Bear hill or mountain	155 55		
Dunderberg mountain	151 40		
Ditto, second summit	148 30		
Ditto, highest summit	145 00		
Ditto, eastern summit	140 42		
High greenstone peak (High Torn)	142 02		
Eastern point of Pallisades	133 15		
Verplanck's point ?	130 39		
Point above	130 05		
Point below Verplanck's point several miles, probably Teller's point	130 55		
Round hill north of Breakneck mountain	332 00		
Point above Breakneck point	323 30		
Point next above	324 30		
Point above the mouth of Fishkill creek (Allen's)	321 30		
a point in Fishkill creek	326 30		
the shore end of Fishkill long wharf	324 50		
the western end of the same wharf	322 48		
Point on the west shore of the Hudson above Newburgh	326 30		
the second and third prominent points as above, five or six miles asunder	331 00		
Deer hill ? summit (about two miles ?)	255 30		
Black-rock mountain peak (about two miles ?)	234 00		
STATION T. *On Quarry point.*			
To Cadets' monument and to a point in Fort Putnam, twenty yards east of station in line	000 00		
Wood's monument	352 30		
Flagstaff	352 35		
Upper or northeast summit of the Crow's Nest	64 30		
Northeast summit of the same	29 30		
Southeast summit of the same	20 45		
Northeast point on the river	13 30		
Upper northeast point on the river	54 00		
Kronk's wharf near the brickyard	112 30		
Kronk's brick-kiln	120 30		
Butter hill, south point on the river	133 15		
Ditto, north point on the river	140 00		
Brick-kiln on the eastern side of the Hudson	221 00		

The primary rocks of Washington and Saratoga counties, like those of the Highlands, are traversed by several transverse axes of elevation and disturbance, and the rocks are more altered in texture and in dip than in other places. Numerous veins and beds of granitic, trappean, augitic and garnet rocks are to be seen in such places. The usual direction is eastwardly and westwardly.

TABLE CONCLUDED.

STATIONS.	Angle.	Course.	Distance.
	° '		
STATION U. *On Anthony's Face point or Breakneck point.*			
To Kosciuszko's monument	000 00		
Cadets' monument	9 30		
Kronk's wharf near the brick-yard	32 00		
Kronk's brick-kiln	41 10		
Kronk's brick-kiln near Station T	349 30		
Kronk's brick-kiln below Cornwall landing	104 00		
Butter hill	72 00		
Ditto south point on the river	57 00		
Ditto, north point on the river	75 00		
the pottery below Cornwall, at the north base of Butter hill on the shore	92 00		
Cornwall landing	119 00		
Round hill back of Cornwall landing	99 00		
Brick-kiln and Clay bank above Cornwall landing	123 00		
Second brick-kiln	137 00		
South point and clay bank at the mouth of Murderer's creek	133 30		
North point, at the mouth of Murderer's creek	137 30		
Point above the last on the shore of the bay	154 00		
Point below New-Windsor	160 00		
New-Windsor	164 00		
the southwest point of Polepel's island	163 35		
Brick-yard on the eastern shore of the bay, and about three hundred and fifty yards distant	192 00		
Toll-gate and mouth of creek one mile below Newburgh	179 30		
STATION V. *On southwest point of Polepel's island.*			
To Kosciuszko's monument	000 00		
the pottery below Cornwall landing	26 30		
the brick-kiln below the same landing	42 00		
Cornwall landing	62 30		
First brick-yard above	86 30		
Second brick-yard above	99 00		
Third small brick-yard near Cornwall landing	79 00		
South point of mouth of Murderer's creek	110 00		
Clay bank	116 00		
North point of the mouth of Murderer's creek	118 00		
Point above	147 45		
Point south of New-Windsor	157 00		
New-Windsor	164 45		
Round hill back of Cornwall landing	68 00		
Deer hill ?	66 00		
Hill north of Breakneck, in line with Cornwall and Round hill back of it, and with this station.			

The angles observed from the summit of Bull hill, New Beacon, Old Beacon, Black-rock mountain, Devil's peak, and several others, have been lost. The distances between these points as stations had been calculated from the original and secondary bases, and some of these lines were used as bases for the determination of the location and distances of some of the principal hills, mountains, localities of minerals, and particular rocks; the position of the small lakes, ravines, valleys, streams, etc.

(E). ORES OF THE HIGHLANDS, AND OF THE MOUNTAINS OF SARATOGA AND WASHINGTON.

Magnetic iron is the only ore of any great economical importance known, but there are some beds of limonite, some of pyrites and of arsenical iron. Lead, silver and tin ores are said to have been found, but I have seen no indications to justify the conclusion that they occur in any important quantities. The beds of pyrites have already been described as localities of sulphate of lime and alum, on pages 114 and 119 of this volume; it is unnecessary to repeat them. Copper pyrites and carbonate of copper have been observed in small quantities.

MAGNETIC OXIDE OF IRON.
- (*a*). Highlands east of the Hudson.
- (*b*). Highlands west of the Hudson.
- (*c*). Mountains of Saratoga and Washington counties.

(*a*). MAGNETIC OXIDE OF IRON EAST OF THE HUDSON.

This ore is confined to the Highlands, and abounds in Putnam county. Several mines are already wrought, and many more are capable of exploration. They form masses in gneiss and hornblendic gneiss rocks, which, by casual examination, would be called beds; but after a careful investigation of the facts, I think they may be called veins. Their course is parallel to the line of bearing of the strata, and they lie parallel to the layers of rock: but by close examination, it is found that in several instances, after continuing with this parallelism for a certain distance, the ore crosses a stratum of rock, and then resumes its parallelism; then crosses obliquely another, and so on. In other places, where a great bed of the ore occurs at some depth, only a few small stripes of ore penetrate through the superincumbent mass to the surface, as if the rocks had been cracked asunder, and these small seams of ore had been forced up from the main mass below. The beds or veins of magnetic iron ore lie either vertical, or dipping to the east-southeast, at an angle corresponding nearly to the dip of the strata. One example only was observed where its dip was to the west-northwest, viz. at the Stewart mine. The ore is very variable in quality. In some it is nearly pure magnetic oxide of iron; in others, it is intermixed more or less with the materials of the contiguous rocks; in others, it is mingled with pyrites and with other minerals. Two main veins of this ore will be described under the names of the Phillips vein and the Simewog vein. Numerous localities are known where this ore occurs, and where it has been dug in small quantities. They will be mentioned under the head of local details.

Local Details.

A bed of magnetic oxide of iron has been opened on Breakneck mountain, and several tons taken from it. The extent of the bed is not known, and the ore has not, it is believed, been smelted.

Another bed has been opened on the northeast part of Constitution island, opposite the West-Point foundry.

Another was opened in the middle of the island. The ore occurs disseminated in granite near the redoubt, above the Target rock on Constitution island. Magnetic oxide of iron is thickly disseminated in limestone, near Phillips's mill, one and a quarter miles east of West-Point; and it is found in that stratum of limestone in many places, from the above locality to near half a mile south of the "Cotton rock," a distance of three miles.

It also occurs in the granite rock that is associated with the augite and limestone rocks near the old "Silver mine," three-quarters of a mile southeast of Conshook island, and one mile northeast of Anthony's Nose mountain.

A bed was opened many years ago on Anthony's Nose mountain, but it contained much pyrites and crystallized phosphate of lime, both of which injure the ore for the manufacture of iron.

The brown spar at the "White mine," about one mile east of the western summit of Anthony's Nose, contains magnetic oxide of iron disseminated.

A locality of magnetic oxide of iron occurs on Mr. Tilly Foster's farm, two and a half miles southeast from Putnam court-house. The ore forms a large part of a hill about one hundred yards long, ten to forty feet broad, and elevated twenty to thirty feet above the ground adjoining. Some hundreds, perhaps thousands of tons of ore can be easily procured at this place, without digging below the level of the hill. It is associated with serpentine, with limestone containing brucite or boltonite, and with green mica. The mass of ore is bounded by gneiss on the east; and serpentine, limestone and verd antique seem to form its western boundary. It was thought that some *chromated oxide of iron* was observed here, but no examination has been made to ascertain that point. Prof. Beck has probably analyzed the ore, and detected chromium if it exists in it.

Another ore bed was discovered some years ago about half a mile southwest of the preceding, on land belonging to the Misses Fowler. Some tons were dug out, but I do not know whether any has been smelted. The ore is here mixed with manganesian garnet, augite and hornblende.

The Simewog vein passes through Simewog hill, and was traced one and a half miles south-southwest on Mr. Jedediah Wood's farm; and it is supposed to continue still farther south-southwest, as ore has been dug in that direction about one mile south-southwest from Mr. Wood's house. The variation of the compass at this place has been described at page 117 of this volume. This vein was formerly extensivcly worked at Simewog hill, and the mine is called Townsend's mine.

This mine was the first known and first worked in this part of the country. The ore was carted to great distances, and shipped on the North river, to some of the towns on Long-island sound, and various parts of the country. The largest portion of the ore was carried to Danbury in Connecticut, and was there an article of traffic. It has not been wrought for twenty or thirty years, in consequence of other beds having been found in more convenient locations for smelting and transport. Fifty thousand tons of ore, at least, have been taken from this mine, estimating four tons to the cubic yard; and one hundred thousand tons more may probably be taken from the vein in Simewog hill, without going below the level of the small stream which flows across the ore bed. Should it ever be necessary to obtain this ore in quantity, (as is probable, from the prospect of the New-York and Albany railroad passing up the valley on the east side of the hill,) at least one million tons may be calculated on, above the water level of the Croton river, which flows along the base of the hill, and free from the expense of drainage, by driving an adit level from the level of the Croton, a distance of three hundred or four hundred yards to intersect the vein.

This vein of ore has also been worked to the extent of several thousand tons, near the road and north of the little stream mentioned above as crossing the vein. The vein here is from eight to fourteen feet thick, and nearly vertical in position, between strata of gneiss and hornblendic gneiss which dip seventy to eighty-five degrees to the east-southeast. On Simewog hill, one-fourth of a mile south, the vein is from three to twenty feet thick, associated with similar rocks and with granite. It has been wrought on Simewog hill from thirty to sixty feet or more in depth, over a length of three hundred to four hundred yards. It is scarcely doubted, from the observations made, that this vein is at least two miles in length, with an average width of six feet. Its depth cannot be estimated, but it is presumed that the labor of ages could not exhaust it in depth, as the bottoms of such veins have never, in any country, been found. In the estimates above, the calculation is based upon the vein being wrought down to the water level of the adjacent valley.

This ore bed seems to be a vein, although its strike is the same as that of the strata. In the excavations on Simewog or Mine hill, the bed or vein seems to have crossed the strata very irregularly and obliquely, as represented on Plate 5, fig. 12, and similar to the lead vein in the Shawangunk mountain at the Sullivan mine, running between the strata for a certain distance, then crossing obliquely between two other strata, and so on.

The *Phillips vein* has been traced at short intervals for about eight miles, and is presumed to be continuous through this distance, except where it is interrupted by dykes and transverse heaves of the strata. Many mines have been opened on this vein, and several of them are now worked.

The Coldspring and Patterson turnpike crosses this vein of iron ore near the crest of the mountain, about nine miles from Coldspring landing. There is an opening near the road, and near this crossing, where some ore has been dug. Here the ore seems injected in little sheets, veins and beds, through the gneiss rock, so as to form one-fourth to three-fourths of its mass through a horizontal thickness (as the strata are vertical) of thirty to thirty-five feet. Pyrites abound in a portion of the bed. The ore is easily traced along its course, as it shows

itself distinctly along the line of bearing of the strata, disseminated, and forming black stripes in the rock. Near the house, one or two hundred yards farther south-southwest, another small opening has been made. One hundred to two hundred yards farther south-southwest on the line of the vein, a larger excavation has been made, and five hundred to eight hundred tons of the ore thrown out; but it is here so much intermixed with pyrites as to be unfit for smelting, until the pyrites shall have decomposed. Some hundred yards farther south-southwest on the line of the vein, another opening has been made next the marsh, and is continued down the hill. The ore is here more or less intermixed with the rock, with a breadth of ten to twenty feet, and the gneiss and hornblendic gneiss rocks associated dip to the east-southeast at an angle of about sixty degrees.

Farther down the hill are two main openings, which go by the name of Phillips's mine. The ore in some parts of the upper mine is more or less intermixed with copper pyrites, which injures the quality of the iron. The mine has been wrought badly, timbers being used to prop the overhanging rock, and great masses have crushed in and filled most of the mine.

The lower mine, where the whim is placed, has a solid rock roof, a part of the ore bed having been left in the top of the hill, while the mine has been worked below. The ore bed is here fifteen to twenty feet wide, and has been wrought thirty to forty feet in depth, over a length of —— yards. This mine is not worked open to the day like a quarry, but a drift crosses the strata to the mass of ore, and it is worked at and below this level, along the course of the vein under a cover of rock. The ore does not show itself very distinctly in the overlying rock. The ore here is nearly a pure magnetic oxide of iron, and twenty thousand to thirty thousand tons have probably been taken from these two mines.* Other openings have been made along the line of the vein for about half a mile farther to the south-southwest, and some three thousand to five thousand tons of ore probably removed. The rock in which this part of the vein thus far described is contained, is mostly felspar, with some bluish quartz; hornblende is also common. The felspar is sometimes pearly in lustre and grey in color, with wrinkled and bent faces, as if it had been soft, and subjected to forces acting in different directions.

Other openings along the course of this vein were traced for half or three quarters of a mile in a southwesterly direction. Hornblende abounds in the rocks associated with the iron ore.

The next mine that is worked to any extent on this vein, is the Stewart mine. It is about twelve feet thick of pure ore, and four feet more of lean ore. The former is much used in forges, the latter in the blast furnace. The ore at this mine is purer than that of any other mine I have seen, and is easily worked in the forge. It is granular, and easily broken and crumbled into grains about the size of BB shot, and is called by the miners "shot ore." The vein lies between strata of felspathic gneiss, which dip to the west-northwest about seventy degrees. This mine is on the east side of the mountain crest, and about one hundred to two

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* Green hornblende, actynolite, green hyalite, green and blue carbonate of copper, pyritous copper, crystallized magnetic oxide of iron in the form of the acute rhomboid, common pyrites, and acicular gypsum (efflorescent), were seen in large quantities at these mines.

hundred feet above a marsh, with a steep declivity, and might easily be wrought to that depth without drainage, by driving an adit level to intersect the vein.

About half a mile south-southwest is another opening by the road side, where some ore has been dug; but it is lean, and much intermixed with the gneiss rock.

About three-fourths of a mile south-southwest of this is the Denny mine. It is about two and a half miles east-northeast of Warren's tavern in Phillipstown, in a straight line on one of the crests of the eastern ridge of the Highlands. The ore seems to have been injected among the rocks. In some places it forms regular stripes on the surface of the rock, parallel to the line of bearing; in others, there are scarcely any indications on the surface, while extensive masses exist a short distance below. This cap of rock over the ore is frequently called by the miners a *rider*, and the ore below, the *horse*. The mine now at work north of the house, is about thirty feet deep, and the vein of solid ore twenty-five feet wide, overlaid by a cap or rider of rock which contains but little ore. The position of the ore, the cap or rider, and thin strings of ore on the surface, are indicated on Pl. 5, fig. 7. Most of the ore is very compact and pure, but some contains hornblende. Much of the felspathic rock contiguous to the vein is injected with thin veins of ore from one-eighth to one inch thick. Two hundred yards south-southwest is another opening, from which much ore has been taken. This place has been excavated to a depth of sixty feet, and the vein is twenty to thirty feet wide. Twenty thousand to thirty thousand tons of ore at least have been removed.

Contiguous to this opening is another thirty feet deep to the water, with a sheet of rock five or six feet thick, between two divisions of the vein (Vide Plate 5, fig. 8). The rocks on each side of the vein are more or less injected with thin veins of ore. From examining the locality, many suppose that the ore has been injected into the cracks and crevices of the rock when broken up by some upheave. This ore is delivered at the Coldspring furnace, and at the wharf at Coldspring, for three dollars per ton; and mined as it is, scarcely any profit can be realized at this price. The quantity mined here is six hundred tons per annum.*

The Coalgrove mine is about one or one and a half miles south-southwest of the Denny mine; it is in gneiss. The vein is narrow at the surface, but at the depth of twelve feet it is four feet wide. The ore is of an excellent quality, very rich, and well adapted for the forge, and will undoubtedly make an excellent iron. The distance from this mine to the furnace and Coldspring landing, is less than from the other mines.†

The Gouverneur mine is about one and a half miles south-southwest of the Coalgrove mine, and four miles east of the Phillips manor house, at the southeast corner of the "water lot." The ore is much intermixed in the rock, but would perhaps work well, mixed with other ores to flux out the felspar and other minerals. It may probably be purer farther down-

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* Mere holes are dug down in this ore bed or immense vein of iron ore, and water accumulates unless pumped out, or drawn out by a tub and whim. By the present mode of mining, two men, a boy and horse, are required to tend the whim for drawing up water and ore; when if properly worked, the same quantity of ore could easily be wheeled out by one man or boy, or carts could enter the mine and load, and dispense with this kind of labor entirely. A small and short adit level from the hill-side east of the mine, would lay the ore bed dry for a hundred feet or more in depth for a considerable distance.

† The Kemble mine is a short distance north-northeast of the Coalgrove mine, and on Phillips's vein.

It has been opened in several places along the crest of the mountain to a depth from three to twelve feet. The ore is disseminated in the gneiss and granitic rock, through a thickness of five to twenty feet. The strata are nearly vertical. It is on one of the crests of the eastern ridge of the Highlands, west of Peekskill hollow.

A slight opening has been made about three-fourths of a mile north-northeast of the Gouverneur mine, between that and the Coalgrove mine. The ore is titaniferous, and in lumps and disseminated in the rock. The vein is six to twelve feet wide. It may perhaps be worked by picking the ore, so as to separate the lumps from the gangue.

The mines and openings just described are the principal ones on the Phillips vein, but the ore can be found along almost the whole line. It follows the crest of the east ridge of the Highlands a distance of at least eight miles. The breadth of this vein has been mentioned at different places from three to thirty feet wide; its average is probably about twelve feet, and its length, as now known, about fourteen thousand yards. If the mean average of the vein be supposed to be half its bulk of ore, every cubic yard will contain about two tons of ore, and would yield at least one ton of iron, or each yard in depth would make fifty-six thousand tons of iron. The vein, by proper working, can be mined to a mean depth of one hundred yards, without expense of drainage, more than the proper opening of adits. We may place the workable produce of this vein above the water level of the adjacent valleys, at 5,600,000 tons of iron.

The phenomena of the mines in many places on this vein induce the idea of igneous injection, connected with a powerful upheaving force. The felspar is often pearly, wrinkled, and with bent laminæ. The appearance of hyalite, a mineral usually associated with volcanic and trap rocks; the apparent injection in veins among the seams and crevices of the rock; the appearance of the softening of the gneiss and bending its layers like a flowing slag, seem to point to an igneous origin of this vein. It often has the appearance of a bed, and at other times of a vein ramifying from a main mass between the strata, and at other times cutting obliquely across them, but still having its outcrop parallel to the line of bearing.

The Coldspring furnace is the only blast furnace in operation in the counties of New-York, Westchester and Putnam. It is supplied with magnetic oxide of iron from the Phillips mine, the Denny mine in Putnam county, and from the Townsend mine in Canterbury, and the O'Neil mine in Warwick, Orange county. These ores are mixed in certain proportions, and flux each other easily with a small addition of the Singsing limestone. The produce of this furnace is from one thousand to fourteen hundred tons of pig iron per annum.

Bonnell's forge in Phillipstown is believed to be the only one in operation in the counties under consideration. It is supplied with the shot ore of the Stewart mine.

(*b*). Magnetic oxide of iron ore of Rockland and Orange counties.

Magnetic oxide of iron ore abounds in the mountain region of Rockland and Orange counties. It is generally found in that species of primitive rock so common in the Highlands, and often called granitic gneiss or gneissoid granite. It lies in beds and layers in this rock, having its line of bearing and its dip. Where it exists in layers, they are from one inch to twenty feet in thickness, in some places alternating several times with the layers of rock; where it is found in beds, the magnitude of the largest has never been ascertained. In the line of bearing, the extent of this ore is not yet well ascertained. Most of the localities of this ore are on three or four lines which extend across these counties from northeast to southwest. Sometimes the lines are not continuous, but are dislocated by lateral heaves. Their continuity has not been traced throughout, and much time and minute observation would be necessary for a perfect development of the veins.

One of these veins ranges along the northwest face of the Highlands, and the mines on Butter hill, Deer hill, and probably those of the Clove mine, O'Neil mine, and Forshee mine may be on this vein. The other ranges from the Forest of Dean mine north-northeast to Kronkite's mine, Meek's mine, and the ore bed near West-Point. The ore beds on Constitution island are believed to be a continuation of this vein. The same vein is supposed to range from the Forest of Dean mine southwestwardly by the Greenwood mine, or else the Hassenclever mine, Patterson mine, Mountain mine, Long mine, Crossway mine, Sterling mine, and ———— mine to the New-Jersey line. Another range of ore seems to extend from the north side of the Crow's Nest, where a mine has been opened by Round pond, and so on towards New-Jersey. Another still probably ranges from Fort Montgomery by Queensbury mine, and Rich mine, to New-Jersey.

Local details.

A bed of magnetic oxide of iron occurs about one or two hundred yards east of the reservoir at West-Point. Its quantity is not known, as no explorations have been made. The indications there are as promising as at many productive mines. The ore is associated with hornblende. It has been traced at short intervals for some distance in a southerly direction towards Meek's mine on the west part of Bear hill, southwest of Buttermilk falls.

At *Meek's mine*, the ore is titaniferous.

Kronkite's mine, on the farm of Richard Kronkite, esquire, is about half or three-fourths of a mile southeast of his house, and four and a half miles southwest of West-Point. There are two veins of ore separated by a sheet of rock. Mr. K. has traced it fifty to eighty rods to the north-northeast. Eight hundred tons of ore were taken from this mine about thirty-five years ago, and it is said to have made iron of a superior quality. The ore is very rich, and the veins (separated by rock where they have been opened) vary from a few inches to ten feet thick. They range north-northeast, and dip about seventy degrees to the west-northwest. This place is three miles from Fort Montgomery.

The *Round-pond mine* was opened many years ago, about one-fourth of a mile northwest of Round pond, and a considerable quantity of ore taken out, which appears very pure, and a good forge ore. Another opening was made a few years ago within one hundred yards of the northeast part of Round pond, and several tons of ore taken out.

Gneissoid and granitic rocks are associated with the iron ore at all these localities, and hornblende is a common mineral in the gneiss.

The *Forest of Dean mine* is about three miles southwest of Mr. Kronkite's mines, and about six miles west-northwest from Fort Montgomery. It belongs to George Ferris of New-York, and has been worked for many years. The ore forms a bed or vein of great size parallel to the strata of gneiss, and these dip to the east-southeast about forty to sixty degrees. A peculiar kind of granite is associated, but it seems to form imbedded and capping masses to the mass of ore. Excavations have been made, and ore taken out over a breadth of about one hundred and fifty feet; and at the depth of fifty to seventy feet, it is said the ore is a solid mass of that breadth. This bed of ore seems to be extensive and inexhaustible. Forty thousand tons of ore at least have been taken from this mine, and it seems as if a commencement of working it only has been made, if the bed be as broad as the indications and workings render probable. The nature and position of the rocks at this mine are illustrated on Plate 5, fig. 9. The ore has been removed in some places to the depth of sixty or seventy feet. The water is pumped up, and the ore raised up by means of a water wheel carried by a small stream a few rods west of the mine. The mine became very wet a few years ago, and was abandoned. The price of ore is kept so low, that it must be favorably located and easily mined to make it profitable. It is probable that this bed may be opened in many places in the vicinity. The same bed, it is supposed, associated with the same rocks, was seen about two miles farther up the stream to the southwest.

The *Greenwood mine* is two miles southeast of the Greenwood furnace in Monroe. It is in the granitic gneiss. These layers of ore, separated by a few feet of rock, are exposed. The middle one of these only is sufficiently uncovered to reveal its thickness; this one is nine feet. This mine is covered by what some miners call a rider; that is, rock lying nearly or quite flat, or hanging in a direction contrary to the dip of the ore and rock in which it lies. This rock roof covers this mine; after its removal, the ore and its walls lie conformably, that is, dipping to the southeast. The ore is mostly compact and hard, containing considerable sulphur, and requires roasting. It is associated with quartz, hornblende and mica. Preparations are making to use it extensively.

At Greenwood furnace the rocks are gneiss, with many masses of hornblende, augite, coccolite, and mica imbedded. In the vicinity of the beds of iron ore about one-third of a mile east of the furnace, several excavations have been made for the ore, which is more or less mixed with pyrites, and with slight traces of copper ore. Beautiful coccolite, and large crystals of mica and augite, have been procured from some of these excavations.

"*Long mine* is about five miles southwest of Southfield furnace, and two and half miles west of the saw-works. This mine has been known since long before the Revolution, and is the only one in the county at which any thing like systematic mining has been attempted.

This ore has its bearing and dip corresponding with those of the rock. Only one layer of the ore has been worked, which is six feet thick. The ore is strongly magnetic, and said to be as good as any in the Highlands. It is associated with hornblende, sahlite, slaty gneiss, gneissoid hornblende and reddish granite; has a small quantity of pyrites; requires roasting, and gives a red short iron. This mine has been worked three hundred yards in length, and about forty in depth. The early working has all caved in, but fine pillars of ore sustain the hanging wall where the work has been recently prosecuted. Vast quantities of ore have been taken from this mine, without any appearance of its failing. It belongs to the Messrs. Townsend. Only one dyke has ever occurred in this mine; it was one foot thick, and made no change in the direction of the ore. It cannot now be seen; is worked seventy feet deep.*

"*Long mine* was discovered in 1761, by David Jones; it has never been bottomed in any place. It is traced over a mile in length; is wrought forty rods in length; general width sixteen feet, consisting of two parallel layers, with a waving *slab* of rock between them from four to twelve inches thick. In this forty rods a dyke has been found, of what Mr. Townsend calls an imperfect flint, two feet thick, standing perpendicularly, and crossing the ore at right angles; (it is now covered.) All the ore similar; yield always sixty-two per cent. Average amount of ore used, five hundred tons; this, in seventy-five years, gives thirty-seven thousand five hundred tons taken from this mine. Its iron is remarkably tough, clean and strong; cost of mining from fifty cents to one dollar per ton. The iron of Long mine has been much used for cannon, muskets, wire, steel, and fine malleable iron. It has also been cast into harness buckles, and after annealing, proves exceedingly tough and strong."†

Dr. Beck, describing this mine, says,—"This is situated about five miles southwest of Southfield furnace. The ore occurs in gneiss rock, and follows the general direction and dip of the strata, and is never at right angles to them. The bed has been very extensively worked; but owing to injudicious management, the old *workings* are at present closed. Recently the mining operations have been conducted in a more skilful manner. Pillars, or supports of the rock or of the ore itself, are left at intervals, while the excavation is continued in a nearly horizontal direction. The accompanying rock is exceedingly variable in its character. Sometimes the felspar greatly predominates; at others, the quartz prevails; and again at others, mica, of a blackish color, is the principal ingredient. The floor of the bed approaches to mica slate; its course is nearly north and south, and its dip to the east.

"This ore is of a bluish black color, and has minute grains of quartz disseminated through it, which causes it to give fire with steel. It breaks in columnar fragments, and being of a granular structure, is without much difficulty reduced to coarse powder; and when in this state, it is strongly attracted by the magnet. It does not, however, possess polarity. The average specific gravity of the ore is 4·885; and with the exception of the siliceous particles, it is entirely soluble in hot concentrated muriatic acid.

"The results of the analysis of this ore show that it is of an excellent quality. It is highly

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* Dr. HORTON, Third Geological Report of New-York, 1839, pp. 163, 173. † Ibid, 1837, p. 19.

esteemed for the furnace, and is said to furnish pig iron, which is easily rendered malleable by the processes now employed for that purpose. Under these circumstances it is gratifying to be enabled to add, that this bed is of great extent, and if judiciously worked, will undoubtedly yield a vast amount of ore.

Analysis of the magnetic iron from the Long mine, Orange county.

Protoxide of iron	25.40
Peroxide of iron	70.50
Oxide of manganese	1·60
Silica or quartz, and loss	2.50
	100.00

These proportions of protoxide and peroxide of iron are equivalent to 68·50 per cent of metallic iron."

"The *Patterson mine* is half a mile southwest of Long mine; ore very similar in all respects; makes excellent *red* short iron; is in the granitic rock. The ore is twenty feet thick; opened one hundred and fifty feet long. About ten thousand tons of this ore have been used. It is strongly magnetic, and has polarity. About the middle of the mine, as now open, is a transverse slip or *heave;* the mine and its walls appearing as if they had slid downwards and forwards to the southeast, causing an angle in their line of bearing. This mine was discovered in 1831, by John Patterson. One thousand tons have been raised annually. Its ore is used principally to melt with infusible and bad ores, as O'Neil and lean limonitic ores. Its iron is good.

"*Mountain mine, Antone mine, Conklin mine* and *New mine,* are a group from twenty-five to fifty rods northwest and north from the Patterson mine, belonging to the same proprietors. They lie in nearly parallel beds; the ore of all apparently similar—a rich black magnetic oxide, possessing polarity. Ore to the amount of five thousand tons has been used from these mines; the ore and walls nearly vertical; layers of ore from four to eight feet thick. The new mine has a cap of rock lying nearly horizontal. Associated minerals, sahlite, hornblende, and felspar. The sahlite is laminated and very beautiful; iron red short.

"The *Mountain mine* was discovered in 1758, by a hunter, in consequence of a tree being blown up by the roots; yield forty-five per centum; iron remarkable for strength and *fine polish;* cost of mining, one dollar per ton. Two dykes cross this mine at an angle of forty-five degrees, each fifteen inches thick. Before the Revolution, when this mine was chiefly worked, the iron was sent to England to be used for tinning.

"*Crossway mine* is four hundred or five hundred yards southwest of Mountain mine. This bed is fourteen feet thick, and has been wrought sixty-five feet deep and one hundred and fifty yards in length; ore and iron very similar to those of Patterson mine; moderately *red short;* ore and walls nearly vertical. Twenty-eight thousand tons are supposed to have been used from this mine. Associated minerals, hornblende, epidote, mica and adularia. This

mine was found in 1793, by John Ball. It yields about fifty per centum of iron good for casting, and malleable iron "*

The Antone mine is a continuation of the same vein as the Crossway mine.

The Patterson, Mountain, and Crossway mines seem to be the same bed of ore, but hove out of place by successive faults parallel to the strike, as is represented on Plate 5, fig. 10. The same rocks and minerals, and the same intervening sheets of rock in the ore, were observed.

" *Sterling mines* are about a mile southwest from Crossway mine, at the south end of Sterling pond. These mines, or *this vast mine*, is in the northern end of a mountain of moderate elevation; its length is about three miles. The ore is *rich*, granular and compact; its product, *cold short* iron; is one of the earliest known iron mines in the United States. The minerals connected with this ore are crystallized green hornblende, sahlite, green mica, flesh-colored felspar, and the ore in octohedral crystals. The rocks are granite, and a coarse showy sienite. There is abundant evidence of great disturbance in the stratification in this mountain, and in all the vicinity. The rocks dip to the northeast and east, with the ore conformable to this arrangement; at least such is the general arrangement, so far as can be ascertained in this mass of confusion. The ore alternates with the rock; how often, cannot easily be ascertained. The ore lies naked about fifty rods wide by one hundred and fifty yards in length. In many places its surface is even and polished, as if it had been ground off by the sliding of the rocks."*

The naked smoothed ore shows the drift scratches very distinctly in some places. The course was not measured, but it is believed from recollection that their course is nearly north and south, or north-northwest and south-southeast.

" *Sterling mine*, discovered in 1750, by whom unknown; named after Lord Sterling, the then proprietor of the soil; he sold, and a blast furnace was immediately put in operation by Messrs. Ward and Colton, that is, in 1751; cost of mining is thirty-seven and a half cents per ton. Its yield is always fifty per centum, in the blast furnace. Amount of this ore used has ranged from five hundred to two thousand tons annually; the medium of this gives 137,000 tons as the amount of ore used from this mine; at present the amount used is two thousand tons. The ore always fuses easily; its iron is between *cold* and *hot* short, very sound and strong. It has been largely used for casting cannon, and for making bar iron. No proper dykes in the mine; it lays on the side of a mountain. The ore, in different places where opened, is from ten to twenty feet thick, inclining at an average angle of thirty degrees. The floor is smooth granitic rock, a little over three feet thick; rests on another bed of soft rich ore, and the little used proves free of sulphur. (I may add from my own knowledge *positively*, that another immense bed underlays the last mentioned. *W. Horton.*) Sterling mine covers a surface of more than thirty acres, by survey; part of this the ore is

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* Dr. HORTON, Third Annual Geological Report of New-York.

bare, part is covered by soil from one to five feet in depth, and part by rock from six inches to a yard or more in thickness."*

A topographical sketch of the vicinity of the Sterling mines may be seen on Plate 30, fig. 4. It is not pretended to be accurate, as it was sketched from memory since I was there, but will give a general idea of the localities. The rock of this region is the peculiar grey granite of the iron regions in the Highlands. Near the south end of the pond, on entering the valley at the outlet, the strata are seen to be transverse, viz. ranging northwest and southeast, and dipping about six to twelve degrees to the north-northeast, as is represented by the arrow point on fig. 4, and on the section fig. 5. This may be seen distinctly at the mines, a few rods from the south end of the pond. From the stream at the line of section southward, the ore bed is either naked or covered with soil on a thin cap of sienite of one or two feet thick. It has been worked in many places on the hill-side, as represented by the letter D on fig. 4 of Plate 5, and is from ten to twenty feet thick. It is exposed about three hundred yards along the hill-side, with a breadth up and down the hill of about one hundred and fifty yards from the brook. It is supposed that five hundred thousand tons of ore can easily be procured at this place. It has little or no covering of rock, so that it may be worked as an open quarry, without any expense of drainage. Some of the ore contains pyrites, but a large portion seems to be very pure.†

The Sterling, Mountain, Crossway, Patterson, Antone, Conklin and New mines, are all represented on the topographical sketch, Plate 30, fig. 4. They all seem to be the same original bed or vein of ore, but the rocks have since been subject to such derangements as to displace them.

"The *Belcher mine* is upon the same property, and very similar ore to that of Sterling; it makes *cold short* iron. It is one and a half miles southwest of Sterling mines, and at the southern termination of the same mountain. The ore has been worked about one hundred and fifteen feet wide, without finding a rock wall on either side. It is believed to be a prolongation of Sterling mine. This mine was found in 1792, by Jacob Belcher; ore yields forty-eight per centum; iron cold short; cost of mining thirty-seven and a half cents per ton; ore well adapted for making bar iron by the blooming process, for which only it has been used."‡

"*Red mine* or *Spruce-swamp mine* is nearly three miles south of Long mine. All the ores of this mine are magnetic and full of pyrites, so much so that only a moderate amount has been used. They decompose rapidly when dug up and exposed to the open air. In this manner the surface of this mine has all been reduced to powder of an iron rust color; like several other mines, the ore alternates with the rock. This mine was discovered in 1780, by J. Stuperfell; cost of mining fifty cents per ton; ore sulphurous; being remote, not

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* Dr. HORTON's Report: Third Annual Geological Report of New-York, 1839.

† Beautiful specimens of crystallized green hornblende were found abundant in a thin bed of sienite, between two beds of the iron ore.

‡ Dr. HORTON's Third Annual Geological Report of New-York.

much used; iron sound; has been generally used as a flux, mixed with hard black oxides and refractory *cold short* ores; it assists fusion, and improves the quality of the iron."*

The *Smith mine* was opened in 1828, about one and a half miles south of Kronkite's landing, between the Crow's Nest and Butter hill. The ore is native magnet. The bed or vein is three or four feet thick, and dips with the gneissoid rocks in which it is contained. It was worked by Mr. Smith of Fort Montgomery, who dug some tons of the ore. It has been abandoned for reasons unknown. The ore of the ore beds of the Highlands is every where associated with gneiss, or granitic gneiss and hornblende.

Magnetic oxide of iron is also found of good quality in many places in Cornwall; but these have not been opened to much extent. Near the foot of Butter hill, on the land of Mr. Clarke; on Deer hill, on the land of Mr. Luke Wood, and that of Thomas Titus, are indications of valuable deposits of this ore.

"The most westerly of the great ore deposits now wrought, is called the *Clove mine*. It is the property of George Wilks, esquire, situated about a mile south of the village of Monroe. It has been open many years, and much ore has been used. The ore is the magnetic oxide. It is compact and granular; the latter is called short ore. The pyrites is more or less disseminated through it. It makes *red* or *hot* short iron. It requires roasting before it can be used. At the south end of the mine exists what is here called soft ore; this is the ore in a black powder. It is taken up with the shovel, ready for use, requiring no roasting process. It would seem to have resulted from the decomposition of the pyrites, and is abundant. The solid ores of this mine are in layers, having the direction and dip and alternating with the rock. The layers are from a few inches to a yard and more in thickness. Several successive layers, and the intervening ones of rock, have been penetrated in three places, a few rods distant from each other. A large quantity of the soft ore has been used. Altogether the mine has been opened about five hundred feet in length, and evidently extends over a much larger surface in all directions. The immediate associates of this ore are mica, hornblende, quartz, felspar, asbestus, occasionally carbonate of lime, serpentine, chrome crystallized in octohedrons; the latter, however, is rare. A kind of soapstone is also connected with this ore."†

The country around this mine is so much covered by a mantle of drift and quaternary deposits, as to render it difficult to trace out any thing very exact in relation to its geological associates. Granite, or granitic gneiss, was observed just on the eastern side of the bed of ore, which is stratified in vertical strata, and composed of magnetic oxide of iron, more or less mixed with pyrites and hornblende. In some parts of the mine the strata between those of the ore are gneiss, more or less loaded with grains of the magnetic oxide of iron. Prof. Beck has described well characterized hematite as associated with the magnetic oxide. I saw none of these ores *associated*, though it was observed at some little distance to the north, under the gravel beds. Beds of grey limestone are to be seen a little west of the limonite or

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* Dr. HORTON, Third Annual Geological Report of New-York. † Ibid.

hematite locality, and not more altered from the calciferous rock of the Champlain division, than the limestone near the Copake ore bed, or that on the eastern side of the Amenia ore bed.

Granite and gneiss, and some sienite, occur still farther to the west, and southwest of the Clove mine. The limestone above referred to, is like that of the valley of the western branch of the Ramapo that flows from Long pond, and like that in the vicinity of the village of Warwick, and on the western side of Bellevale mountain.

"About one mile southeast of the Clove mine, in a straight line, is the *O'Neil mine*, or, as it is commonly called in the vicinity, the *Nail mine*. This is a vast bed of magnetic oxide of iron. It is often in the seams, beautifully crystallized in octohedrons and cubes; the latter are rare. It also contains pyrites, and requires the roasting process. Magnetic pyrites are also occasionally found in this mine; the ore is very hard and compact, the most so of any of our standard ores. This ore is very much esteemed. It makes a good iron, which is of the *red short* description. This mine is the property of Gouverneur Kemble, esquire. Large quantities of this ore are used. The bed is now open one hundred and fifty by five hundred feet. A wall is partially exposed on the southeast side, but no appearance of limit is any where else visible. One dyke has been crossed, which is several feet thick, cutting the bed perpendicularly and nearly east and west. The immediate associates of the ore in this mine are calcareous spar (white and abundant), rose colored garnet, green coccolite, dark colored sahlite and hornblende (massive), arragonite (the flosferri variety), amianthus, and serpentine."*

The O'Neil mine, like the Clove mine, seems an immense mass of ore without any easily traced connection with the adjacent rocks. On the southeastern side, the same kind of granitic gneiss is seen as at the Clove mine. A mass of sienite or felspar rock projects into the mine on the southwest, but it is more than half surrounded by ore, which lies partly on opposite sides of it. The ore lies very irregularly, in some places very pure, in others more or less mixed with hornblende, serpentine, limestone (as calcareous spar, rhombic spar, verd antique, etc.), and various aggregates of these with each other and with other minerals. Some of the ore contains much common pyrites and magnetic pyrites. Slight traces of copper ores were observed in some of the fragments. Much of the ore seems to be an intimate union of magnetic oxide of iron and serpentine, so that it has much the aspect and color of the dark green serpentine; much seems also intimately blended with greenish hornblende.

This mine is a place of great interest to the mineralogist. Many very well characterized and beautiful minerals occur here. The crystallized magnetic ore makes the most brilliant and beautiful specimens of that mineral, of any locality I have ever seen. Many of them in brilliancy, beauty, and richness of color, vie with the richest specimens of the specular iron ore from the Island of Elba. The following minerals were observed at this mine, viz:

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* Dr. Horton's Report: Third Annual Geological Report of New-York, 1839, p. 162.

1. Magnetic oxide of iron, crystallized in large and small octohedrons and druses, over large surfaces in the fissures in the ore, some of them richly iridescent. Some few crystals were *cubic*.
2. Magnetic oxide of iron, compact, pure, and mixed with other minerals, as serpentine and hornblende.
3. Magnetic granular ore.
4. Common pyrites, granular and disseminated.
5. Magnetic pyrites, massive, compact, granular and disseminated.
6. Copper pyrites in small quantities.
7. Carbonate of copper, in small quantities.
8. Serpentine, disseminated in limestone, and massive.
9. Amianthus in veins in limestone and serpentine.
10. Asbestus in the iron ore.
11. Brown spar, crystallized.
12. Rhombic spar, large crystals.
13. Hornblende, crystalline, black.
14. Augite, grey and green.
15. Coccolite, green, very fine.
16. Felspar, nearly black.
17. Felspar, white.
18. Mica, green and black.
19. A mineral believed to be new, supposed to have been analyzed by Prof. Beck.

This mine has been worked since 1823, and has furnished about two thousand tons per annum. The bed seems inexhaustible, as far as we could perceive, as it has been worked only about twenty feet deep, and there is little prospect of reaching the bottom.

"*Forshee mines*. These are half a mile southwest of the O'Neil mine. The mass is composed of a great number of layers of ore, alternating with the layers of rock. The whole hill, which is more than one-fourth of a mile long and nearly as wide, appears to consist of rock and ore, the ore forming a large proportion of the whole. Some layers are granular, forming handsome shot ore; some are compact, and rather more free from pyrites than usual. In these mines are large bodies of the ore in black powder, which is entirely destitute of pyrites. Umber also is connected with the Forshee mines, and appears to be abundant and of fair quality. The minerals associated with the ore of the Forshee mines are red garnet, brown tremolite, green coccolite, serpentine yellow and black, calcareous spar, asbestus and mica."* The strata here dip about forty degrees to the eastward, and gneiss underlies the ore. Its eastern boundary was not traced, but the bed of ore seems to be very thick, with strata of gneiss, hornblende and augite interstratified or interlaminated with it. Nearly the same minerals were observed here and in the vicinity, as at the O'Neil mines. The locality with the large sheets of mica is only about half a mile farther to the southwest; and the rocks west of this mine about half a mile, are filled with crystalline minerals. Garnet and augite abound.

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* Dr. HORTON, Third Annual Geological Report of New-York.

"Five miles southeast of Monroe works is the *Rich iron mine*, the property of Hudson M'Farlan, esquire. It is a fine rich ore, strongly magnetic. It has not been extensively wrought, although there are evidences of an abundant deposit. Connected with this mine are mica, hornblende (or as this mineral is generally called in Cornwall and Monroe, black jack-sahlite), and magnetic pyrites."*

A bed of titaniferous iron ore, much intermixed with a coarse granite or sienite, has been opened on the east side of Bear hill. It was not considered important.

Magnetic iron ore occurs at the Lower landing of Fort Montgomery. It is mixed with a large proportion of sulphuret of iron; in fact the latter seems the gangue of the former. The magnetic sulphuret of iron is found near this place, and is said to be abundant.

Iron ore was seen occasionally along the road from Haverstraw to Queensbury forge; and on the route from Haverstraw to Fort Montgomery, an ore bed is said to occur, containing various curious minerals. The place was not examined, but they are supposed to be the same as those of the neck opposite Consook island, on which the "Old silver mine" has been described. The same beds prolonged would pass through the Tymp, as the gorge between the Dunderberg and Bear mountain is called.

An ore bed is also said to occur within a mile or two of the Queensbury furnace, called the Queensbury ore bed. It was not examined

Peter Townsend, esquire, communicated the following information on the iron mines, etc. of the Sterling tract of land, to Dr. Horton:

"The first furnace on this tract, at Sterling, in 1751, by Ward & Colton, used Sterling ore, until the discovery of Long mine; the first forge at Sterling in 1752, built by Abel Noble, from Bucks county, Pennsylvania. There have been two forges of eight forge fires. Southfield furnace, now in operation, was built in 1806; its annual average of iron is seven hundred and fifty tons, and two hundred and twenty-five bushels of coal to the ton of iron. Sterling averaged annually eight hundred tons of iron, and it was made into five hundred and fifty to six hundred of bar iron.

"Before and during the revolution, the annual production of iron (pig) in this county was fifteen hundred tons, and about one thousand tons bar iron. From 1830 to 1838, there has been made annually in this county three thousand tons of pig, but the bar has been diminished. Steel was first made on this tract in 1776, in the German manner, by the late Peter Townsend, esquire. Pig iron was first used for this purpose, and subsequently bar iron. The first blister steel manufactured in the State of New-York was in 1810; it was made by the present Peter Townsend, esquire, from the iron of *Long mine*. It was used for edge tools, and proved equal to the Danemora Swede iron, called *hoop*. The first anchor made in the State of New-York, was at Sterling forge, in 1773, from iron of Long and Sterling mines.

"The great chain extended across the Hudson at West-Point during the revolution, was made at Sterling in March and April, 1788, by the late Peter Townsend, esquire; it was

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* Dr. Horton, Third Annual Geological Report of New-York.

contracted for, and its making superintended by Timothy Pickering, esquire. The iron of this chain was made from equal parts of Sterling and Long mine iron ores; the weight of each link was from one hundred and forty to one hundred and fifty pounds, and the whole chain one hundred and eighty-six tons, made and delivered in six weeks.

"The first cannon made in the State were by the present Peter Townsend, esquire, in 1816, from the iron of Long mine; they were 6, 12, 18, 24 and 32 pounders. *Not one failed* in the proof; some of them were light field pieces, all for the Government of the United States. The 6 and 12 pounders were made to order, lighter than British brass field pieces of the *same size;* still the metal withstood proof."

The Greenwood furnace and the Woodbury furnace belong to Gouverneur Kemble and others, and use the magnetic ores of the vicinity, mixed with each other in such proportions as are found to work best in the furnace, for the production of the desired qualities of iron. Large quantities of ore from some of the mines in Orange and Putnam counties have been shipped off to furnaces at a distance; principally to those in New-Jersey, where the bog ore is so abundant.

(*c*). Magnetic iron ore of Saratoga and Washington counties.

This mineral is very common in the primary region of these counties, and has, in most places, the general appearance of a stratified rock; but from the localities examined, I am satisfied that it is frequently, if not always, an injected mass, or rather an intrusive rock. Frequently it spreads between the strata of gneiss, and communicates with larger masses like the trappean rocks.

At some of the ore beds, dark brown or blackish garnet, colophonite and coccolite are very abundant, and even form by far the largest portion of the mass of the ore bed; and frequently they resemble the ore so closely, that ordinary observers do not distingush the true ore from those materials intermingled with it. A mine was examined in the town of Fort-Ann, about four miles north of the village, on the top of the mountain, belonging to Mr. Miller and others, in which this fact is well illustrated. Beautiful specimens of the granular ore, granular black garnet, granular and crystalline hornblende, may be procured in abundance. Quartz in irregular roundish masses also occurs in this mass, and seems to have been softened by heat to assume the forms observed. The ore bed is extensive, and parts of it will yield good ore, and the whole mass of the ore bed would yield iron; but if taken as ore for the furnace without careful selection, it will be likely to disappoint the iron-master by its small yield. I think the material might be used in small quantities in the high furnace, with other ores as a flux, and it would also increase the yield of the proper ore by the amount of iron it contains.

There are several ore beds near Mount-Hope furnace, in the town of Fort-Ann, belonging to Mr. Stanley and others. The ore is magnetic, and shows polarity in some instances. It lies in beds, and is sometimes pure, sometimes disseminated in the gneissoid rock contiguous to the bed; at others, it is intermixed with garnet, coccolite or hornblende, and sometimes

with limestone. There are three ore beds southwest of Mount-Hope furnace, near the two ponds, which are connected by a peat bog, and have different outlets, one flowing northwardly by the furnace into South bay of Lake Champlain, and the other flowing southwards into the west branch of Wood creek. A large share of the ore for this furnace is hauled in winter on the ice across these ponds and the marsh. Indications of ore were seen near the furnace, and it is probable that it might be obtained in abundance much nearer the furnace than the mines from which it is supplied.

Mount-Hope furnace is the only high furnace in Washington county. There are several forges where anchors and other work are made, on the waters of the west branch of Wood creek. Some of the iron is made from the pig, and some from ore brought from Essex county.

A good ore bed is said to have been discovered near Comstock's landing. I did not see it, and did not know of it until I had left that part of the county.

Another is also said to have been discovered north of Dake's corners, in Fort-Ann.

Another locality was indicated to me on the shore of Lake Champlain, two or three miles south of Putnam ferry, in Dresden; but I did not find the right locality, or else there was a mistake in the nature of the material described to me. The rocks along the shore between that place and Putnam ferry were observed to contain grains of magnetic oxide of iron disseminated, but no locality was seen there that would justify exploration.

Garnet, in a granular form, is so abundant in some of the granitic rocks near Putnam ferry, and near Rogers's rock, as to make the name of garnet rock an appropriate one. This kind of rock, however, is local, and generally on or near a transverse axis of elevation.

A large body of iron ore exists in the mountain south of the mouth of the Sacandaga river, and about two miles south of Hadley's falls.* These veins were examined and described by Mr. Seymour. He reported that there were ten or fifteen veins of the ore, and that those opened were five to eight feet wide. He mentioned that the Porter vein that was opened became wider as they descended below the surface, and less mixed with its gangue, which is felspar. The ore is said to make very tough and soft iron, and superior even to the iron of the Arnold ore bed. He reports the veins as ranging due north, lying nearly vertical; while the strata range east-northeast, and dip about thirty degrees to the north-northwest. The ore is magnetic, and yields thirty to forty and fifty per centum. The eastern mines are owned by Dr. Mitchill of Fish-house; the western, which are more accessible, belong to Messrs. M. Jeffers of Hadley, and A. B. Fay of Fish-house.

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* Hadley's falls are indicated on our county maps as being several miles below Jesup's landing, while they are several miles above, and just above the mouth of the Sacandaga river.

(F). LIST OF MINERALS OBSERVED IN MAKING THE EXAMINATION OF THE COUNTY OF ORANGE, BY W. HORTON.

Amianthus, in Amity; at the O'Neil mine, and at Greenwood furnace; and Clove mine in the town of Monroe.

Arragonite, at Edenville; one mile and a half west of Newburgh; and at the O'Neil mine in Monroe.

Arsenical iron (massive), Edenville and Amity.

Asbestus, at Mount Eve, and at the Forshee and Clove mines.

Augite crystals, at Two-ponds; at Greenwood furnace; two miles southeast of Greenwood furnace; at Fort Montgomery; and in Edenville and Amity.

Bog ore, in the towns of Blooming-grove, Goshen and New-Windsor.

Boltonite, two miles and a half southeast of Monroe works; at the Two-ponds, and the Forest of Dean, in Monroe; four miles west of West-Point, in Cornwall; and four miles southeast of Woodbury furnace (fine specimens).

Brown and red hematite, or limonite, in a bed two miles and a half west of Canterbury; also a quarter of a mile north of Clove mine, Monroe; at Bellvale, four miles east of Warwick; and near New-Milford, three miles southwest of Warwick.

Brown spar, in the village of Warwick; one mile southeast of Warwick; and at Hampton, six miles southeast of Newburgh.

Brucite, in Amity, and one mile south of the same; one mile north and one mile northwest of Edenville.

Cacholong, four miles east of Warwick.

Calc spar, four miles southeast of Woodbury furnace, in Monroe.

Calc or rhomb spar (white), in Amity, and at the O'Neil mine; (red), in Amity; (red and white), two miles east of Greenwood furnace, in Monroe.

Chalcedony (white, yellow and blue), four miles east of Warwick.

Chrome chrystallized in octahedrons, at the Clove mine, in Monroe.

Cinnamon stone, one mile southwest of Amity.

Clintonite, in Amity, and one mile southwest of the same.

Coccolite, four miles west of West-Point; at the Forest of Dean, in Monroe (beautiful black specimens); at Greenwood furnace; two miles east of Greenwood; two miles southeast of Greenwood; one mile west of Monroe works; at the Forshee mines; in Amity; at the O'Neil mine in Monroe, and Rocky hill in Warwick.

Crichtonite, one mile south of Amity.

Diallage, one mile south of Amity.

Epidote (crystallized), one mile north of Southfield furnace; at the Long mine, and four miles southeast of Warwick.

Felspar (red), at the Sterling and Patterson mines, at Two-ponds in Monroe, at Buttermilk falls in Cornwall, and at M'Gee's hill in Warwick; (white), four miles west of West-Point; (adularia), three miles southeast of Monroe works.

Felspar crystallized, in Amity; one mile east of Amity; at Rocky hill in Warwick, and one mile north of Edenville.

Fibrolite, at Queensborough, in Monroe.

Fluor spar, one mile east and one mile southwest of Amity, and one mile north of Edenville.

Galena, at Fall brook in Deerpark.

Garnet, one mile southwest of Amity; at the O'Neil mine and at Two-ponds in Monroe, and two miles east of Warwick.

Hornblende (crystallized), at Sterling and Two-ponds, in Monroe; in Amity; at Mount Eve; one mile north of Edenville; one mile northwest of Edenville; one mile southeast of Amity; one mile south of Amity, and one mile southwest of Amity.

Iceland spar, one mile southwest of Amity.

Idocrase, in Amity; one mile southeast, and half a mile south of Amity; and one mile north of Edenville.

Iron pyrites (cubes), two miles southeast of Warwick.

Iron pyrites (cubic), at Carpenter's point, and four miles north of Newburgh.

Iron pyrites (massive), at the Clove, O'Neil, Greenwood, Rich iron, Forshee and Spruce-swamp mines, all in Monroe.

Iron pyrites, two miles southeast of Warwick, and at Sugarloaf and Snake hill in Goshen.

Iron pyrites (white), in crystals, at Rocky hill in Warwick.

Jasper (red, yellow and black), at Bellvale, four miles east of Warwick.

Kaolin, one mile north of Southfield furnace in Monroe.

Kyanite, at Rocky hill in Warwick; two miles southeast of Warwick, and at Queensborough in Monroe.

Labradorite, one mile southwest of Phillipsburgh; in Walkill; half a mile northwest of Washingtonville in Blooming-grove; in Warwick, and four miles south of Goshen.

Lydian stone, at Canterbury in Cornwall.

Magnetic iron ore (crystallized), at the O'Neil and the Sterling mines, in Monroe.

Magnetic iron ore (massive), at the O'Neil, Forshee, Sterling, Belcher, Crossway, Spruce-swamp, Mountain, Patterson, Long, Greenwood, Rich iron, Horsenclever, Forest of Dean, and Clove mines, all in Monroe.

Magnetic iron ore, at Green's and at Titus's mines, on Deer hill, in the town of Cornwall; also two miles east of Warwick; in Amity; and four miles southeast of Woodbury furnace, in Monroe.

Magnetic pyrites, at the O'Neil mine, and the Rich iron mine, Monroe.

Meionite, at the Two-ponds and the Forest of Dean, in Monroe.

Mica (greenish white), at the Forshee mines; (green), at the Clove and Sterling mines; (black), at Greenwood furnace; (red), Mount Eve.

Orpiment, one mile north of Edenville.

Oxide of titanium, one mile southwest of Amity, and one mile and a half southeast of Warwick.

Pargasite, in Amity; two miles northeast of Greenwood; at the Two-ponds and the Forest of Dean, in Monroe; four miles west of Westport, and four miles southeast of Woodbury furnace, both in Cornwall.

Phosphate of lime (crystallized), Amity and Edenville.

Plumbago, in Amity.

Plumbago (radiated), three miles southwest of Saw-works in Monroe.

Pseudolite, one mile southwest and one mile south of Amity.
Quartz crystals, in Blooming-grove, Warwick and Goshen.
Rhomb spar (red), at the Two-ponds in Monroe.
Sahlite, at the Forest of Dean, Rich iron, Long, Mountain, Patterson, Sterling and O'Neil mines, all in Monroe; and three miles southeast of Greenwood furnace.
Sapphire, one mile east and one mile south of Amity.
Satin spar, in Blooming-grove, and five miles south of Goshen.
Scapolite crystals, at the Two-ponds and Greenwood furnace, in Monroe; one mile and a half north of Edenville, and in Amity.
Scorodite (drusy), Edenville.
Serpentine, at Queensborough, and at the Forshee mines, both in Monroe; two miles northwest of Sterling in Warwick; one mile south of Amity; one mile southwest, and one mile east of the same; and at the O'Neil and Clove mines in Monroe.
Sphene, in Amity; one mile southwest of Amity; one mile north of Edenville; at Rocky hill in Warwick; four miles southeast of Warwick; four miles southwest of the Saw-works, and at Two-ponds, both in Monroe.
Spinelles, two miles east of Greenwood, in Monroe.
Spinelles (black), in Amity, one mile south of Amity, half a mile west of Amity, one mile north of Edenville, at Mount Eve, two miles and a half southeast of Monroe works, at the Two-ponds in Monroe, four miles west of West-Point, at the Forest of Dean, and four miles southeast of Woodbury furnace; (red), in Amity, half a mile southeast of Amity, and one mile west of the same; (grey), one mile southwest of Amity; (green), in Amity.
Sulphate of lime, one mile north of Edenville.
Talc, one mile southwest and half a mile southeast of Amity.
Tourmaline, one mile north of Edenville, one mile southwest of Amity, and at Rocky hill in Warwick.
Tourmaline (yellow), one mile southwest of Amity.
Tremolite (green), one mile north of Edenville; (brown), one mile north of Edenville, and at the Forshee mines in Monroe; (white), one mile north of Edenville, and one mile southwest and one mile southeast of Amity; (grey), one mile southwest of Amity.
Warwickite, one mile south of Amity.
Zircon (brown), at Mount Eve; (red), at Deer hill in Cornwall, in Amity, and one mile north of Edenville; (red and white,) at M'Gee's hill; (black), at Rocky hill in Warwick, and one mile northeast of Amity; (black, enclosed in white), at Rocky hill.*

* Manuscript Notes of the Geological Survey of the First District, Vol. viii, p. 395.

Opinions of Dr. Horton on the Superposition, &c. of the Rocks of Orange County, N. Y.

The following opinions were expressed by Dr. Horton, after making the geological examinations of Orange county, in 1838; and they are, in the main, correct. The equivalency of many of the rocks had not then been determined with certainty, and his observations had been mostly confined to Orange county.

That the slate and greywacke interstratified with it are cotemporaneous.

That the grit of Shawangunk mountain rests *unconformably* upon the bassetting edges of the argillite and greywacke.

That the limestone series at the foot of Shawangunk mountain and Carpenter's point reposes *conformably* upon the grit.

That the greywacke of Deerpark* reposes *conformably*, but with less dip, upon the preceding limestones.

That the *Neelytown* limestone is a bed in the argillite.

That the blue limestones of Newburgh, Monroe, Blooming-grove, Goshen and Warwick, *if strata*, are *interstratified* with the slate and greywacke.

That the conglomerate and fossiliferous limestone of Goshen are *newer* than those last mentioned.

That the *grit* and the greywacke of Pine hill, Skunemunk mountain, of Blooming-grove, and of Bellvale mountain, are *newer* than the *greywacke*, interstratified with the *argillite*, *because* (like Thompson's limestone) they rest *upon* the former, and are piled up into lofty mountains.

That the ends of all our primitive ridges subside *gradually* to the north: *Attested* by the direction of our streams; by the eye when on elevated situations; by the position of our transition and secondary rocks resting on their subsiding points; and by our anticlinal lines.

That some of our rocks, to all intents and purposes, are *sandstones* of the oldest period.†

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* These belong to the Erie and Catskill divisions.

† Manuscript Geological Notes of the New-York Survey of the First District, Vol. viii, p. 427.

(G). DIARY OF A GEOLOGICAL SURVEY OF THE ISLAND OF NEW-YORK, BY L. D. GALE, M. D.

In describing the rocks of the island of New-York, page 518, a regret was expressed that Prof. Gale had not communicated his detailed observations on that island, so as to enable the reader to visit interesting localities. I have since found his diary of observations, and it is herewith subjoined.

On Tenth Avenue.*

August 24, 1838.—Commenced the survey of the island on the west side, beginning at the corner of the 10th avenue and 14th-street. This is near the northern limits of the populated or populous portions of the city, on the west side, and is chiefly made grounds by filling in on the river banks, and occupied only on the east side.

16th-street: Natural ground and lots covered on both sides with buildings, and so continues to Chelsea square, or 20th and 21st-streets.

In 24th-street is a boulder of asbestos rock, of four or five feet diameter; the soil hitherto, gravel and sand. Boulders are greenstone, granite and sandstone, with here and there other kinds, as the asbestos rock (that is, the *Hydrous Anthophyllite* of Torrey). From 24th-street northward it is mostly unsettled, but here and there a house or hut.

In 25th-street, and right of the avenue, is a boulder of sandstone nine feet long, five feet wide and seven feet high, coarse grained, or the size of a pea, well stratified.

31st-street: Here the gneiss first makes its appearance, and on the east side, then on the west a few rods higher up. Strike north and south; dip vertical. Tortuous, with veins of quartz six to twelve inches wide, and veins of granite from one to fifty feet, and from that to seventy-five feet wide, and continuous from two hundred to three hundred feet north and south; and extends somewhat above the surface, filled with cross veins of quartz running in every direction, and easily broken out with crowbars. The granite is of rather indifferent quality and coarse texture, containing much felspar, coarse crystals.

32d to 33d-streets, or opposite the New-York chemical works, and from this point to the northward as far as to 50th-street, the granitic veins are so abundant as to constitute the largest portion of the rock in many places.

In many places the gneiss is worn away, and the granite projects many inches above: a good hint for builders in selecting stone to resist the action of the elements. The granite of this vicinity, in general, is not of a quality that will answer for facing in fine work. It extends from the 10th avenue to the waters of the Hudson, but dips below the surface in many places in the intermediate space. It is to appearance the same material as that found

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* Manuscript Geological Notes of the Survey of the First District, Vol. viii, part ii, p. 1, et seq.

in boulders in almost all the southern part of the island. As we go northward the rock improves in quality till we reach 50th-street, and much of it is used for facings on the line of the aqueduct, for culverts and the various works on the island. The dock opposite Fisher's glass-house is used for getting the stone to the river. On the banks of the river the strata are very tortuous, and the shore is rock-bound from this place to Manhattanville, with the exception of here and there a few rods covered with soil or sand.

42d-street: Here we first notice the drift furrows. They are on the east side of the avenue. From glass-house northward two hundred yards, and fifteen yards wide, is a fine vein of granite, suitable for fine cutting, and in many places may be got out in cubic blocks of ten feet on a side. This is especially the case at 48th-street, where it is of better quality than in any other place hitherto examined. The extensive bed in this neighborhood extends from the 10th avenue to the river, with a pretty regular descent. The gneiss on the banks of the river is finely exposed. The strata are full of veins of quartz and granite, and are exceedingly tortuous. Most of the veins are parallel with the strata, but from the granite and quartz being protruded amidst the gneiss, has greatly disturbed its strata.

Blasting and digging.—Blasting and removing solid rock commands from ninety to one hundred cents the cubic yard, and loose earth from twelve to twenty cents the cubic yard.

Anthophyllite locality.—From 48th to 58th-street, on the shore, the granite deteriorates in quality, and the gneiss increases in proportion, and the quality is so poor that it is not of much value except for filling in. About 57th-street, and extending from the 10th avenue to the river, the rock changes in character, and though in general character it is like gneiss, the material or mineral character is entirely changed; it becomes of a soft and fibrous texture, fragments and boulders of which are found on almost every part of the island, and called by the inhabitants of the city radiated asbestos. A specimen of this has been sent by Professor Torrey to Dr. Thompson, of Glasgow, who analyzed it and pronounced it *Anthophyllite*. This rock extends from 59th-street, following the strike, which is north 30° east; varies from this to due north and south as far as 63d-street, where it dips down and disappears below the river. The locality of this rock is therefore bounded on the north and south by 59th and 63d-streets, and east and west by 10th avenue and the river. The rock varies considerably in character in the different places where it has been uncovered, and occupies a series of conical hills, some five or six in number, distributed in a northerly and southerly direction. In some places, as at 60th-street, it is talcose in structure, and may be split into thin slabs; in others, it is dark grey, almost black, composed of straight fibres arranged in a columnar form, meeting and crossing each other frequently at right angles.

Another variety of this rock is that which has obtained the name of *Radiated Asbestos rock*, and the kind above referred to as analyzed by Dr. Thompson. It is generally of a light grey color, consisting of fibres radiating from a centre, and the radii from half an inch to two inches in length.

The hills containing the anthophyllite are considerably higher than the adjoining grounds. The rock in the east and southeast portion of the anthophyllite locality above pointed out, is

indistinctly stratified, and that on the north and southwest portion is well stratified, and rests side by side with the gneiss. In the extreme northwestern portion, where the fibres are finer than in the east, it was attempted some ten years ago to work the rock for soapstone, to be applied to the various uses of this article in the arts; but it proved to be too hard, and the attempt entirely failed, as it is said, to the ruin of the man who attempted it. Notwithstanding this, the locality of this rock was not known to scientific men until quite recently, although boulders of great size have been found in almost every part of the island.

It is quite remarkable, that at the junction of the anthophyllite with the gneiss, it is so sudden that there is no intermixing of the two, but each remains perfectly distinct, side by side, a stratum of anthophyllite and a stratum of gneiss, and each pursuing its own peculiarity within the space of three or four inches of its neighbor.

32d to 63d-street: Having followed the banks of the river from the chemical works, or from the vicinity of 32d-street to 63d-street, we return and ascend the 10th avenue.

From 32d to 37th-street, on the avenue, is a hill of some forty to fifty feet in height, of solid gneiss, containing large veins of coarse granite, too shaky to admit working into finished work. Strike north to north by 10° east. Dip west 80° to 90°.

From 37th to 42d-street, is a valley to be filled up. It contains, from the avenue to the river, many huge granite boulders, ten to fifteen feet diameter, angular surface, and apparently little worn.

42d to 44th-street: The gneiss and granite mixed in great confusion, so that it is almost impossible to recognize the strike or dip, which are very near the same as at the last observation, namely, strike north to north 10° east, and dip nearly vertical.

44th to 47th-street: Mostly granite, and especially on the west side, appears above the surface of the soil, and large quantities are put into shape for the Croton water-works. It is of a tolerably good quality, but not equal to that on the block above.

47th to 48th-street: The same rock (granite) continues on both sides, but is the most abundant on the west. Here the gneissoid structure entirely disappears; nothing but granite is seen except here and there as a vein, or thin stratum. The granite is of a superior quality, and occupies more than a block north and south, and east and west from the 10th avenue across the 11th avenue nearly to the river, the whole or nearly the whole appearing from the indications on the surface to be sound and workable granite, of a superior quality. It resembles the Hollowell granite, but has a somewhat coarse texture.

48th to 49th-street: The rock is gneiss, with large veins of granite, from ten to twenty feet wide, and of good quality for working into fine work.

49th to 50th-street: The rock more purely gneiss in structure, but the materials are more granitose than those in the last block.

50th to 56th-street, or about this point, the rock dips far below the surface, and reappears as we go north near 58th-street, and is continuous above the surface from thence to 62d-street. It is all gneiss, containing here and there a vein of granite. The gneiss is fissile, and very tender, so that much of it is broken up with crowbars.

63d to 101st-street: As the survey of the 10th avenue extended north only to 63d-street, in pursuing a northerly course we leave the 9th avenue, which is open only to 48th-street, and take the 10th avenue and that portion between it and the Hudson.

63d to 64th-street, and from 9th avenue to 10th, the gneiss is seen in place. Strike N 10° W, and dip vertical.

10th avenue is at 63d-street gneiss, regularly stratified, abounding in veins of granite. Strike N 30° E. Dip W 80°.

64th to 66th-street: Valley partly filled up; boulders sandstone, greenstone and anthophyllite rock.

67th-street: Gneiss in place. Strike N 30° E. Dip vertical, contorted and confused, from the intrusion of granite veins.

68th to 69th-street: Strike N and S. Dip W 80°. Here the gneiss is loose and tender, full of granite veins, decomposing and falling to sand.

70th-street: The rock has been uncovered, and exhibits distinct drift grooves and scratches in abundance. Direction of furrows N 35° W. Strike N 30° E. Dip vertical. This is in front of A. Dalley junior's hotel, in the village of Bloomingdale.

Again from 10th to 11th avenue, on 70th-street, the gneiss has strike N 35° E, traversed by veins of granite.

70th-street, from 11th avenue to river. Strike N 10° E. Dip W 85° to 90°.

Here we leave the avenue as such, and take up the west side of the island, from Bloomingdale road to the Hudson, and from 70th-street on the south, to 101st-street on the north, following the banks of the river in a northerly direction, and returning by the Bloomingdale road; and as the streets cannot always be found on the river side, we shall give only approximations, with a note of interrogation, at each, where they cannot be definitely pointed out.

On the banks of the Hudson, at 70th-street, the gneiss with granite veins is abundant. Strike N 30° E. Dip vertical. Veins three to ten feet thick, and quartz veins from one to four feet thick, often separated by thin films of mica. As we go north and opposite the Asylum for the orphans, the rock is more purely gneiss. Dip vertical, and strike as last.

75th-street: Strike N 30° E. Dip vertical.

77th-street: Strike and dip same as 75th-street. Abounding in quartz veins and strewed with boulders of greenstone, quite angular and rough; and *drift scratches*, N 40° W; numerous, and extending almost every where in favorable situations, into the river even below the lowest tide-water marks, and again to the highest elevations on the island. Here the strike of the gneiss is N 20° E, and the dip vertical. Given direction of the grooves N 30° W. Surface covered by grooves from thirty to forty feet east and west, and twenty to thirty north and south.

A little sketch of the vicinity is given, with the direction of the drift scratches here referred to. (Vide Pl. 37, fig. 2.) It is in the opening, or cleared lands, lying on the Bloomingdale road, between Bloomingdale village and Manhattanville, and but a few rods north of the public house known as *Burnham's hotel*, and extending from the road to the river.

At the quarry, opposite Burnham's, the rock, which is gneiss, has a dip of 50° to 80°

west, and the strike is N 35° E. At Nos. 2 and 3 (vide Pl. 37, fig. 2), the drift furrows are large and deep; direction N 35° W; and again at No. 1, they are also distinct, and have the the same direction.

At No. 2, Pl. 37, which is about two hundred feet north of that represented at No. 4, is a rock of gneiss, which is the highest point in the neighborhood. The top of this rock presents a surface in a northerly and southerly direction of sixty feet, and east and west of eighty feet, and is by estimation seventy feet above the tide waters of the Hudson, and from three hundred to four hundred feet distant. Over the whole surface, and at an angle of 60°, and 120° with the strike, are drift grooves from half an inch to an inch in depth, and from forty to sixty feet in length, and from one to six inches wide, and remarkably distinct. The direction is N 35° W, and strike N 25° E.

In another rock at 3 (Pl. 37) about fifty feet north of the last, and of twenty feet less elevation, the grooves are three inches deep, and from five to seven inches wide. Direction of the grooves N 35° W; strike N 25° E, and the dip nearly vertical.

About four hundred to five hundred feet northwest of 3, Pl. 37, is the gneiss rock on the banks of the river, represented at No. 1, where the rock extends to the water and dips beneath it, and again disappears under the soil about ten feet from the water, and six feet above its level. The scratches are as distinct as any I have ever seen. Direction N 30° to 35° W, and cover a surface north and south of thirty to fifty feet.

Again on the heights, three hundred to five hundred feet farther north, and in a northeasterly direction from No. 1, at John K. Howland's country seat, on the rocks a few rods, say twenty, north of his house, are to be seen similar grooves, and running in the same direction.

Again at the place next north of Howland's are similar grooves, running N 25° W. These are on the precipice of the rock, eighty feet above the water, and three hundred feet distant.

Again on the water's edge, opposite the last, grooves are seen in direction N 30° W, and extending two hundred feet north and south on the shore.

From Howland's, six hundred or eight hundred yards north, the gneiss dips to the west 80°, and the grooves are quite abundant. One of these measured six feet long, eight inches wide and four inches deep. Boulders of greenstone and sandstone are abundant, all along the shore.

From Howland's northward to Webber's, the last place corresponding to 101st-street, the gneiss rock is constantly in sight on the shore, and during almost the whole of the distance covered with grooves, running in direction varying from N 30° to N 45° W, but rarely more than N 30° or 35° W.

Ninth avenue.

Ninth avenue commences a little below 14th-street, and is graded upwards to 23d-street; sparsely settled to 16th-street, and densely from 16th to 22d-street, or to the block above Chelsea square.

22d-street upwards, or northerly, scarcely settled ; here and there a house.

22d to 23d-street: On both sides are large quantities of boulders, say one-third sandstone, one-third greenstone, and the rest granite, anthophyllite, jasper, rock, &c.

23d to 29th-street: Imperfectly graded, with high banks of gravel and boulders as before mentioned, in kind and quantity very angular, indicating less attrition than those found on the east side of the island.

All the lower portions of this avenue, up to 39th-street, are either made ground or gravel, sand, or loam. Materials are the same as the boulders, but containing more mica.

29th-street: The gneiss makes its appearance above the surface. Strike northwest and southeast. Dip on east side of avenue east 85°. Here the avenue is open, but not graded.

36th-street: The rock appears ten feet above the grading, and extends north and south two hundred feet, and again dips below in every direction. Strata much contorted, with veins of quartz and granite protruding through it in every direction. In some places the granite amounts to one-half the entire mass.

38th to 39th-street: The rock appears above the surface, with the materials of granite and the stratification of gneiss.

42d-street: The rock has been uncovered, and is gneiss, with veins of quartz protruding from it. Strike N 1° to 10° E. Dip W 75. Surface inclining to west; surface one hundred feet east and west and two hundred feet north and south. Looked for drift furrows, but saw none. Rock was rough, as if it had been disintegrated on the surface.

44th to 46th-street: Drift abounding in boulders of compact sandstone, greenstone and granite. There has been no levelling of consequence above 44th-street, except to render the avenue passable. On the west side, the rock appears towards 10th avenue, four hundred feet north and south, and one hundred and fifty east and west. Strike N 20° to 30° E. Dip W 70° to 80°. Gneiss with veins of coarse granite, of inferior quality generally.

48th-street: The avenue is only open to this street. Here the rock appears a coarse granite, but only seen in patches.

52d to 53d-street: The rock also appears at, and occasionally above, the surface. Strike N 15° to 20° E. Dip vertical. Rock gneiss, with granite veins.

53d to 55th-street: Valley, used as garden.

55th to 56th-street: Gneiss appears with strike N 30° E. Dip 80° W.

56th to 57th-street: Strike N 30° E. Dip westward 80°. Rock seen two hundred feet north and south.

58th-street: Valley damp ; elevations east and west, but still the whole on elevated grounds.

62d-street descends, on the north, into the valley of the Bloomingdale road, and meets it at or near 63d-street.

Eighth avenue.

Eighth avenue commences at 13th-street, and is settled sparsely to near Bloomingdale road, or to 63d-street.

15th-street, and west side of avenue are numerous boulders in the open grounds. Some eight or ten of these are of the dark ferruginous anthophyllite, and are from three to eight feet diameter, much worn, and very smooth on those faces which resist decomposition by the weather.

15th to 16th-street: Open grounds; most of it is made land, and where natural soil, it is sand and gravel.

28th-street: Gneiss appears above the surface, with veins of granite. Strike N 30° E. Dip W 80° to 85°, and disappears a few rods north.

28th to 30th-street: Alternations of sands and pebbles, containing largely granite, greenstone and sandstone fragments of all sizes.

36th-street: East side the rock is gneiss and granite, a fair workable material for common work, and much may be got out for facings. Strike N 10° E. Dip W 85° to 90°.

38th-street: Granite and gneiss; a quarry east side of avenue, twelve to fifteen feet deep, not wrought at present; somewhat tortuous. Strike N 8° to 10° E. Dip 85° W. Twenty-five rods further east gneiss again. Strike north and south. Dip 75° west. Apparently fair rocks for diluvial grooves, but none were observed from 38th-street to 40th-street.

41st to 42d-street: The rock is a coarse granite, but very sound, six to ten feet above grading; in sight one hundred and seventy-five feet east and west, and four hundred and ten feet north and south.

Northward from 42d to 49th-street, the grounds are pretty level.

50th-street: The rock is gneiss, highly stratified and fissile. Strike N 20° E. Dip 80° to 85° W. On the east side are boulders of anthophyllite of the dark ferruginous kind.

54th to 55th-street: Gneiss appears ten feet above the surface, and has the strike N 30° E. Dip W 60°. Well stratified, not tortuous or containing veins.

58th-street: The gneiss is twelve feet above the surface of grading, and strike N 30° E. Dip vertical. Drift furrows east side of avenue, and west of the Bloomingdale road, and within a few rods of the junction.

Near the junction of the road and avenue, but towards the northwest of it, and at the distance of say one hundred yards, the gneiss has been worn down to great depth by the materials that have travelled over it; grooves are distinct, and wonderfully so for a diameter of two hundred or three hundred feet, in every direction, all in fair view of the road, and on the northeast side the grooves cover almost the whole rock, but are most apparent on the west side; and this last remark applies equally well to all the grooves on the island. Direction of the grooves N 45° W. Strike N 30° E. Dip vertical. This rock contains veins of fine granite, one to ten feet wide, and the part recently uncovered has been worn completely smooth. Other grooves are seen near the Bloomingdale church. Direction N 45° W.

Again farther north near Mr. Huddart's school, on the same road, west side. Direction N 45° W.

Again twelve to fifteen rods north of Burnham's hotel are grooves very finely characterized. Direction N 45° W. They are on the east side of the road.

Again near J. H. Howland's seat, grooves east side of the road. Direction of grooves N 45° W. Strike N 30° E. Dip vertical.

A few rods south of six-mile stone, on west side of road, the grooves in pure gneiss, direction, as before, N 45° W. Strike N 40° E. Dip vertical.

Near Mr. Francis' country seat (still north of the six-mile stone) and corresponding with 96th-street, on the east side of the road, the grooves perceptible only. Strike N 30° to 35° E. Dip vertical.

97th to 98th-street, and opposite to the house of Mr. John Darks, the gneiss is well stratified, appears on the east side of the road, and is covered with grooves. Direction of the grooves N 45° W. The rock uncovered extends north and south one hundred and twenty feet, and east and west twenty feet. Dip W 80°. Strike N 35° E.

Near 103d-street found boulders of the anthophyllite, dark variety, with others of greenstone, granite, &c.

Again near 109th-street, grooves on east side of the road. Direction N 45° W. Dip vertical.

On the heights, a little before we reach the Lunatic Asylum, and the west side of the road, the grooves run N 45° W. They are an inch and a half deep, and six to eight inches wide. Strike N 35° E. The same grooves seem to be continued to the east side of the road, for the rock continues two hundred feet northeast and southwest, and is covered with grooves as above, running N 45° W. This rock occupies the enclosures of Mr. Stevens, whose house is on the east side of the way, and may be recognized by having an immense boulder of granite resting on the rock near the southwest corner of the house, and is nearly round, having a diameter of between ten and eleven feet. There is one very large groove between this boulder and the northwest, whence it came. It seems to have been cut by this very rock, inasmuch as it terminates with the boulder on the southeast, and is covered by the soil in less than a rod from the boulder. This groove is three inches deep and eighteen inches wide. There are a great abundance of others side by side with this, but none so large. The gneiss is very compact, and suitable for building.

Directly by the lane leading to the enclosures of the Lunatic Asylum, the gneiss again appears above the surface. Strike N 30° E. Dip 85° to 90° E. Grooves also abundant, and running N 45° W.

Again opposite 116th-street, grooves running N 45° W. Strike N 30° to 25° E; twenty to thirty feet north and south, uncovered.

We now leave the road and proceed on the heights south of Harlem and Manhattanville valley, to 8th avenue.

Leaving the road at the southern limits of the village of Manhattanville, kept on the height of land which skirts the southern border of a valley which entirely crosses the island, and forms the basis of the village of Harlem at its eastern extremity, and that of Manhattanville at its western. The southern border of this valley, which I shall distinguish by the name of Harlem and Manhattanville valley, especially on the western half of it, lies in a direction

northwest and southeast, happening to correspond exactly with the line of the grooves, or perhaps a medium of all those hitherto examined, which it will be seen vary but little from N 45° W. It is proper to notice this fact here. The remaining half of the southern border of this great valley, or that from the 8th avenue on the west, to the 3d avenue on the east, lies, though somewhat irregularly, more nearly east and west. The northern border of this valley extends from the village of Manhattanville on the west, where the valley scarcely exceeds two hundred or three hundred yards in width, to the northern extremity of Harlem village. On the east side of the island, therefore, the Hudson and Mohawk valley extends from 110th-street to 133d-street, while on the western extreme it only extends to the width of about two blocks. The whole is a continuous bed of sand, gravel, pebbles, boulders, and other travelled materials, not unlike those of the southern extremity of the island.

First Fortification.—We reach the first fortification at the distance of some two hundred or three hundred yards from the road, as it descends northward to Manhattanville, and at a distance of about two hundred yards south of the village, and one hundred feet above the waters of the Hudson, and seventy or eighty feet above the village.

On the rock which forms the basis of this fort, and which is gneiss without much foreign matter, are abundance of drift grooves, but none very large or deep. These grooves cover the rock, which is uncovered two hundred feet north and south, and thirty to sixty east and west. The direction of the grooves is N 45° W, and the strike N 25° E. Dip 85° W. This fortification rock is from ten feet to forty feet above the adjoining grounds, being most elevated on the north.

Second Fortification.—Proceeding eastward about two hundred or three hundred yards, we came to another, which we call the second fortification. It is ten or fifteen feet lower than the first. The basis rock (gneiss) is uncovered two hundred and fifty feet north and south, and from thirty to fifty feet east and west. Strike is N 25° E. Dip vertical. Grooves N 45° W. The gneiss is very full of iron rust, apparently having resulted from the decomposition of pyrites. The grooves cover the whole surface of the rock, and are quite distinct, notwithstanding the long and continued action of the elements.

Third Fortification (*faced stone*).—This is on almost the same level as the last, and in direction from it nearly southeast. There is a large surface of gneiss uncovered, the longest diameter being north and south two hundred feet. Strike N 25° E. Direction of grooves N 45° W. Dip W 80°. In this rock are tolerable specimens of adularia.

In the valley between the third and fourth fortifications are grooves N 45° W.

Fourth Fortification (*entirely in ruins*).—This stands on a promontory of gneiss, which projects far into the valley, and lies still farther southeast of the others. It is on this line that the Croton aqueduct is to enter the city, crossing the valley a little east of the valley of Manhattanville. Drift grooves are here seen in abundance, but have been much defaced by exposure. Direction N 45° W. Dip and strike as before.

Proceeding S 45° E, or on a line with the southern border of the valley to its junction

with 8th avenue, grooves are apparent almost the whole distance, but generally less distinct than those at the fortifications.

A few hundred yards north of the new Lunatic Asylum, the rock exhibits most distinct and remarkable grooves for a distance of two hundred feet north and south, and from ten to thirty feet east and west. Strike N 25° E. Grooves N 45° W.

Returning from the Hudson and Mohawk valley on the 8th avenue, we found abundance of greenstone boulders along the south border of the valley, and throughout almost the whole distance from Manhattanville to the avenue.

As we ascend the hill on 8th avenue the gneiss makes its appearance. Strike N 30° E. Dip E 80° to 85°. Grooves abundant south of the rock. Direction N 45° W.

Opposite the woods and south of the second rise from the valley, we find on the east side of the rock, well stratified gneiss. Grooves abundant, N 45° W.

Again at 97th-street, and 80th to 98th-street, near the track, the gneiss is full of grooves, running N 45° W. Rock is on the level with the street. Strike N 30° E. Dip vertical.

96th to 95th-street: East side, six feet above grading, covered with remarkable grooves. Direction N 45° W. Dip vertical. Strike N 30° E. These grooves are more remarkable than any I have seen to-day.

95th to 94th-street: East side, well characterized gneiss, but rather tender, covered with iron rust from pyrites. Grooves N 45° W. Strike N 30° E.

93d to 92d-street: East side grooves. Strike and dip as before. Again near the last, but a little south, say twenty rods, grooves on both sides very large and distinct. Direction N 45° W. Strike N 30° E. Dip 75° E. The rock is uncovered north and south four hundred feet, and east and west from eighty to one hundred feet.

86th-street, east side, forty feet north and south, and fifteen east and west; covered with grooves. Direction N 45° W. Strike N 25° E, and dip vertical. Again eastward in the fields, similar grooves. Direction N 45° W.

84th-street: Similar rock and grooves in every respect like the last.

84th to 82d-street, east side, the rock uncovered to a considerable extent; very tortuous and full of veins. The whole surface of the rock has been smoothed by abrasion, and the grooves are very remarkable, requiring a drawing, as well as the tortuosity. Direction N 45° W.

81st to 79th-street, on both sides of the way, but the grooves are more distinct on the east side. Direction N 45° W. The rocks are much elevated; grooves are few, but large and deep.

77th-street: Rock on the east side insulated, ten rods from the avenue, thirty feet above surface, one hundred and fifty feet long, and covered with grooves. Much weatherworn. Direction N 45° W.

76th to 75th-street: Gneiss well stratified. Strike N 25° E. Dip 80° W. In state of rapid decomposition from pyrites. No grooves seen.

68th to 69th-street: Gneiss more sound, and grooves N 48° W; strike N 35° E, on the east side. Also on the west side grooves N 48° W.

67th to 66th-street: On the west side gneiss unfit for working; grooves abundant. Direction N 45° W. Dip vertical, and strike N 30° E.

66th to 64th-street: Gneiss like last, and covered with abundance of grooves in good preservation. Rock but recently uncovered; is fast disintegrating. Grooves on both sides of the road. Direction N 45° W. Strike N 35° E.

The whole distance from Harlem and Manhattanville valley to the Bloomingdale road, or about 62d-street, on the line of 8th avenue, is extremely rough and rocky. The gneiss is abundantly charged with veins of granite towards the southern portion of the route, while there is little of it in the northern. The grooves are more abundant, and perhaps more distinct, taken as a whole, than I have seen in any part of the island, and should be reëxamined for taking drawings of some of the most remarkable.

Seventh, Sixth and Fifth Avenues.

The above avenues, except the 6th, are only opened to a short distance (21st-street); and as the ground in most of the surfaces is occupied by these streets, it is similar in character. The remarks on one will generally apply to all.

7th avenue commences at the corner of Greenwich lane and Hammond-street. Surfaces composed of loam, gravel and pebbles: here and there a house. The same geological character continues to 21st-street, where the opening terminates.

24th-street: The rock, which is gneiss, with large veins of sandy granite. Strike N 20° E. Dip 45° to 50° W, covered in many places with fine yellow sand.

6th avenue commences at Carmine, near 4th-street, and terminates at Bloomingdale road, at 32d-street, where gneiss has strike N 20° E. Dip 80° W. Not tortuous, but ferruginous.

29th-street: Gneiss makes its appearance. Strike N 15° E. Dip W 80°. Generally sound, and full of quartz veins.

Corner of 6th avenue and 20th-street, gneiss. Strike N 30° E. Dip 75° W.

At 17th and 18th-streets: Have dug twenty feet through; first six feet gravel, then fourteen feet fine sand, and at the bottom came to a dark-blue clay, containing vegetable matter in a state like lignite.

5th avenue, corner of 16th-street, and along 16th-street each way, the gneiss within four feet of grading. Strike N 30° E. Dip 75° W. Strata generally regular.

5th avenue, at 33d-street, gneiss abounding in granite veins, somewhat tortuous. Strike N 20° E, three places. Dip W 80°. The veins contain large imbedded crystals of felspar; veins have protruded and disturbed the stratification. The rock, though exposed, has drift grooves obscured by exposure, but six inches wide and one and a half deep, running north 25° west.

Fourth Avenue.

The 4th avenue commences at 14th-street, or at Union place. The natural soil is, in this vicinity, fifteen to twenty feet above grading, and consists of drift, being an exceedingly confused mass of loam, gravel (last rare), and boulders of immense size, some of which are ten to sixteen or eighteen feet in diameter. Below grading, in many places, the drift loam continues some feet downward, say six to ten, when, if we do not reach the rock, we find a fine sand, not generally white, but of a dark grey, and often containing much mica and grains of hornblende, with quartz and felspar predominating, and indicating that a considerable portion of it had been the result of the disintegration of granite and gneiss.

At the corner of 16th-street and 4th avenue, the gneiss, east side of avenue, appears on a level with grading. Strike N 25° E. Dip W 80°.

18th to 19th-street, patches of loam remain, ten to fifteen feet above grading, with sand here and there, at and below grading.

20th to 21st-street is Grammercy park on the east, towards the 3d avenue, and open grounds either side of 4th avenue. On 21st-street, a few rods from the avenue, is a large boulder of hydrous anthophyllite of a peculiar character, differing somewhat in appearance from that already referred to. It is of a dark or greenish color and spongy texture, but only on the outside; for, on breaking it open, it is compact within, and has indications of limestone and other minerals differing in character from any seen at the locality examined.

25th-street, and twenty-five rods west of the avenue, gneiss appears at surface of grading. Strike N 30° E. Dip 75° W. Drift furrows. Direction N 25° W. Here is an immense boulder of the hydrous anthophyllite, twelve feet long, eight broad and six high, with abundance of longitudinal grooves on its surface.

31st to 32d-street is Sunfish pond, filled up to the level of grading.

32d-street: The rock, which is compact gneiss, appears above the surface, and ten or fifteen feet above grading. Here commences the cut in the railroad, and where the cars, going from the city, exchange horses for steam power. Strike of the gneiss N 25° E. Dip 80° W. The dip varies as we go north, and the rock differs considerably in texture. In some places the dip is 45° W. The first cut of continuous rock ends at 37th-street.

38th to 40th-street, the rock (inferior gneiss) appears, and from 42d-street onward the grade level is from one to ten feet above the natural soil, and this continues to 47th-street.

47th-street: Another cut commences; fifteen feet in the deepest place, reaching the rock, and extending to 50th-street. The soil is drift loam.

53d-street: Rock (gneiss) appears on the east side. Dip 45° W. Strike N 25° E.

66th to 72d-street: Cut ten to thirty feet in drift.

72d to 79th-street: Valley twenty to thirty feet below grading.

79th-street crosses from the East river to 5th avenue, when it terminates in the west.

From 79th-street to the tunnel, the grading is done nearly all the way by cutting through

the gneiss to the depth of from one to twenty-five feet. The strata are exceedingly confused. In the southern part the strike is N 45° E, and dip 45° to 80° W, varying frequently 10° or 20° in dip in forty or fifty feet distance.

Columnar gneiss is seen in many places on the island, but in none more conspicuous than at the south entrance to the tunnel. The columnar structure of gneiss only occurs where the mica is replaced by hornblende. There is not the appearance of crystallization, as in basalt and greenstone; but the fragments have the appearance of old logs, or like the half or quarter of a log, as if split and quartered by art. They are seen in the upper part of the cut, and vary their direction in the distance of a few feet.

97th-street: East of the railroad the rock has been laid bare nearly one hundred feet, and develops drift furrows more than a foot wide and two inches deep. Direction N 45° W. Other rocks in vicinity are found to contain similar furrows, and in the same direction. This was evident on rocks freely exposed to the weather in many places within a few streets of the northern entrance of the tunnel.

From 97th-street to 115th-street, including Harlem creek and the neighboring low grounds, the grading of the railroad is from ten to thirty feet above the natural soil.

101st-street: The gneiss dips down below the surface, and does not appear again till we reach 115th-street.

Between 115th and 116th streets, on the east side, found fragments of a radiated mineral in a vein in gneiss; also epidote in veins in gneiss, but quite inferior specimens. Since found the radiated mineral to be red stilbite, but the specimen was inferior, and could not be so satisfactorily determined as is desirable.

118th to 120th-street, is a quarry of gneiss, which has been used to build a church, standing within a few rods east of the railroad. This rock contains a considerable proportion of limestone. In some specimens the carbonate of lime composes half of the entire mass, and this rock in some places contains distinct crystals of calcareous spar, with some other varieties of crystalline form. The above quarry constitutes a portion of a conical hill of some twenty to thirty feet elevation, which was opened by the railroad passing through its western half, by which a good section of the strata was developed. The strata were found to follow the slope of the hill. They were noticed by me at the time of opening the railroad, and a drawing made, as I considered the appearance interesting.

120th-street commences the last cut in rock before we reach the village of Harlem. Here the gneiss is well stratified. Strike N 45° E. Dip 45° W, and the cut twenty-five to thirty feet deep. The rock is inferior in quality, and has been in some places much disintegrated by pyrites. It contains veins of quartz and granite, and in a few cases rose quartz in veins of two inches wide were found under the bed of the railroad.

Boulders of granular limestone were found when the road was first opened, fragments of which are still to be found in the drift beds on the side of the cut (east side).

This last cut terminates at 124th-street, near the Harlem depot, and does not reappear

until we pass 129th-street, where it rises above the surface of grading, but has been removed by blasting. Enough, however, remains to estimate the strike, which is N 45° E. Dip 80° W.

134th-street: On the banks of Harlem river is the termination of the railroad.

The 4th, or Railroad avenue, passing through the central part of the island, and including some of the deepest cuts hitherto made in solid rock, displays the most interesting part of the geology of its vicinity. I have therefore taken numerous observations on this line, and recorded a sufficient number for the purpose of drawing conclusions with regard to the strike, dip, etc. of any given neighborhood. I have repeatedly traversed the streets (not yet opened) from 4th avenue to 3d avenue, and from 4th avenue to 5th avenue, for differences in character; wherever they have been found, they have been recorded.

Leaving the 4th avenue, pursued course on returning to the city by 3d avenue.

Harlem.

The gneiss approaches the surface in a number of places in the northern part of Harlem village, but southward it does not appear until we reach 104th or 105th-street, and no rock appears in place from 105th-street to 128th-street, and from Harlem river on the east to beyond 8th avenue on the west; the whole being an immense bed of loam, sand and gravel, containing few boulders, or even pebbles of considerable size. It is nearly or quite level, and grows continually narrower as we go westward until we reach the Hudson.

Third Avenue.

Returning by the 3d avenue, we first meet the rock in place between 104th and 105th-street, on the west side, just after we cross Harlem creek (which it will be remembered is not Harlem river; the former is only a small tide stream from Harlem river putting westward two hundred or three hundred rods, crossing 3d avenue near 105th-street), where the strike is N 25° E, and dip 70° to 80° W.

The same rock is in sight frequently from 105th to 94th-street, especially on the east side. Dip nearly vertical. Strike as before, N 25° E.

94th-street, and from that to 105th-street, is a salt marsh, on the east side of the avenue; but from 94th-street southward, the island widens very much.

94th-street to 79th-street: The rock appears in many places on the east and on the west, but varying little in the strike from N 25° E, and the dip is on average vertical. It is hill and valley, with a difference of height of from ten to forty feet, and here and there boulders of greenstone and granite.

At Yorkville, 86th-street, the gneiss is quite elevated, and forms very considerable heights between 3d and 4th avenues, but east of 3d avenue it descends towards the East river. Here

the island projects eastward very considerably, so as to require the laying out of Avenue A, possibly B, at a future day.

Between 49th and 50th-street, ten rods east and one rod west of the avenue, remarkable grooves in each, the strike is N 30° E. Dip 45° W, and the grooves N 25° W.

47th-street, thirty rods east of 3d avenue. Grooves N 25° W. Dip W 75°. Strike N 30° E.

Most of the soil from 3d avenue to the East river is loam, gravel or sand; the gneiss appearing in only a few points, except on the shore. Boulders of granite, greenstone and sandstone, and occasionally white limestone, like that at Kingsbridge. The surface east of Yorkville is undulating, with many conical hills of gravel and sands.

79th to 44th-street: The country is undulating gentle hills and valleys. The gneiss generally appearing on the summits, but of an inferior quality; the strike averaging N 25° E, and the dip varying from 45° W through the vertical to 45° E, but generally vertical or near it. The rock is generally destitute of any veins of magnitude, and unfit for uses in building, except for filling in docks or streets.

43d-street: Grooves on both sides of the avenue. Direction N 25° W. Dip 75° W. Strike N 30° E.

44th to 42d-street: Opposite 44th-street the gneiss appears on east side, ascending seventy or eighty feet in two hundred feet distance, and then sinks down; dips below surface as we go towards the East river. Strike N 45° E. Dip 35° to 40° W. The rock extends to 42d-street.

42d to 36th-street: Valley.

35th to 34th-street: Gneiss on east side. Strike N 45° E. Dip 45° W.

34th to 29th-street: Filled in most of the distance.

29th to 24th-street, and so on to 18th-street, has been graded, and none of the rock appears in place, except one or two instances, where it was reached in excavations for wells and cellars.

18th to 8th-street: The rock does not appear at the surface, but has been frequently reached at the depth of ten to fifteen feet below grading, but I have not been able to get the strike and dip in these cases.

Between 32d and 14th streets and 3d and 4th avenues, or on Lexington avenue: A considerable portion of this plot of ground remains at present unoccupied, and was originally, for a considerable part of the way, covered to ten or fifteen feet deep above grading with drift loam, pebbles and boulders, some of the latter of which were of immense magnitude.

26th to 30th-street: Where the soil has been cut down about four or six feet to grading, the whole surface seems almost completely covered with the boulders it contained, two-thirds of which at least are greenstone, the remainder being granite with a few exceptions. The greenstone were almost universally worn, rounded and polished, while the granite were as generally angular and rough. This circumstance was very strongly marked over the whole space.

On the 3d avenue, west side, and a few feet (say thirty) south side of 16th-street, is a boulder of hydrous anthophyllite, thirteen feet long, eight feet in breadth, and seven in height. It is very uniform in texture, and is covered with drift scratches running generally with the largest diameter.

On the southern side of 14th-street, between Broadway and 3d avenue, is another boulder of hydrous anthophyllite, fifteen feet long, twelve feet in breadth and six in height, containing on its surface drift scratches parallel with the largest diameter.

The above are the largest boulders of this rock hitherto found on the island; but they have been found from Corlear's hook, on the southeast extremity of the island, to as high up as 50th-street on the Bloomingdale road, on the east side of the island, and on the west side from 13th-street on the south to 24th-street on the north.

Section lying between 3d avenue and the river and 2d-street on the south, and 21st-street on the north: Commencing the southern part of the section, we find from 1st avenue on the west and 2d-street on the south, to Avenue C on the east, and indefinitely on the north, is chiefly waste or tilled grounds, graded from six to ten feet above the natural surface. Above 10th-street, however, the waste grounds extend westward to near the 3d avenue.

From 5th-street northward, the above square, as far west as Avenue A, below 10th-street, are the remains of the old Stuyvesant meadows, and as the streets are filled in, the lots are mostly covered with water, and still exhibit remains of the old meadow grass.

The salt marshes which covered the grounds in this vicinity extended westward as far as to the middle of Tompkins square, which is between Avenues A and B, and thence northward at an angle of 45° with the streets crossing Avenue A at 10th-street and 1st avenue at 14th-street, as will be seen on inspecting the map of the salt marshes (Vide Pl. 1, fig. 2).

From 12th-street to 20th or 21st-street, and from Avenue A on the east to 3d avenue on the west, is mostly filled in to grade level on the line of the streets, but many of the lots remain at the old level four to eight feet below. There are still remains of drift hills to be seen; one extending from near Burnt-mill point, or the junction of Avenue D and 13th-street, and running nearly parallel with the street, extends some blocks westward. Another commences near Avenue A, between 15th and 16th-streets, and extends westward and northwestward until it joins 3d avenue from 17th to 19th-streets, having salt marshes both north and south of it; north to 21st-street, and south to 5th-street. First appearance of gneiss east side.

16th-street: Corner of 2d avenue, east side, strike N 40° E; dip W 80°; drift grooves N 25° W. Corner of 3d avenue, east side, strike 35° E; dip W 80°. Corner 4th avenue, east side, strike N 25° E; dip W 80°. 17th-street, one hundred feet west of 3d avenue, within five feet of surface.

Second Avenue.

Bellevue.—At 22d-street, near 1st avenue, the gneiss first appears above the surface as we go northward. The grading for streets has here laid bare a large amount of boulders, of which more than one half are greenstone. These are exceedingly abundant for three or four blocks northward.

The gneiss at 22d-street rises from five to twenty feet above the surface of grading, and is one hundred and forty feet north and south, and eighty feet east and west. Strike N 35° E. Well characterized gneiss. Dip 75° to 80° W.

Drift grooves covering almost the whole rock. Direction N 25° W. Depth one-tenth to three-quarters of an inch; width, half an inch to fifteen inches. It is remarkable that cross seams of granite, cutting the gneiss across the strata, extend from one extreme of the rock to the other, as seen in the sketch (Pl. 37, fig. 1).

The portion of the rock above grading, extends from 21st to 24th-street, and from 1st to 2d avenue. The drift scratches are more distinct at the northern extremity, near the middle division of the Bellevue hospital yard. Here the grooves are from an inch to an inch and a half deep, and from one inch to twelve inches wide. Direction as before. The whole rock is abundant in veins of granite, but they are generally narrow.

On 24th-street, and opposite Bellevue yard, the drift being removed so as to uncover the rock, the latter is found to be of a soft, unctuous substance, and exhibiting three varieties:

1st. Nearly white, and containing much mica; quite as soft as the softest talc.

2d. Somewhat softer than the last, unctuous to the feeling, containing abundance of mica of a bright red, like the deepest peroxide of iron or dark jasper.

3d. Less soft than either of the preceding, and appears like a decomposing or disintegrating gneiss, from decomposition of the felspar contained.

27th and 28th-streets: The rock is a fissile and decomposing or disintegrating gneiss; appears along the northern end of Bellevue enclosures, about twenty feet above grading, and extends to the waters of the East river, where it is twenty-five or thirty feet above, and continues northward to Kipp's bay, with but little variation in character. Strike N 35° E. Dip varies widely in a few hundred feet (being west) from 50° to 80°.

Kipp's Bay.—This bay commences at about 30th-street, and extends northward to 38th or 40th-street. Here the river forms an indentation into the land as far as to 1st avenue by 35th-street, where the rock is a sound and finely stratified gneiss, with few veins. Strike N 30° E. Dip W 45°. The whole rock is covered with drift grooves; they are large and shallow. Some are from twelve to eighteen inches broad, and from half an inch to an inch and a half deep. This rock is now being removed for building purposes in the city.

Near the glass house, but southwest of it, the gneiss appears above the surface covered with grooves N 30° W, half way between 1st and 2d avenue.

Here also a boulder of greenstone thirteen feet long, seven broad and six high; worn very much--smooth.

Elisha Mott's Quarry.—About 37th-street the land extends again eastward, and the rock rises some sixty or eighty feet above tide-water, and continues at or near the same height to the shot-tower, though it occasionally dips down below it.

Near 37th-street and 1st avenue is the New-England glasshouse; further east, on the banks, is a large gneiss quarry, recently worked by Mr. Elisha Mott, but now abandoned. Strike N 45° E. Dip W 45° to 50°. It is a compact and good gneiss for rough work in building.

This quarry is about two hundred to three hundred feet north and south, and eighty feet east and west and fifty feet in depth, and still considerably above tide-water at its base.

Northward on the cliffs the rock is from twenty to sixty feet above tide-water, and generally covered with thin soil except in the valleys. The strike, in a great number of observations, varied from N to N 40° E, and the dip from 45° to 75° W.

On the old road to the public house called "Cato's," forty rods southwest of the house, and on the southerly side of the track (it lies between 49th and 50th-streets, and about ten rods southeast of 3d avenue, vide page 595), there are abundant drift furrows. The rock crosses the track and appears on both sides, but the furrows are most distinct on the southeast side, covering a surface forty-two feet wide and two hundred feet long. Direction N 25° W. Same grooves and same direction west of avenue.

48th-street to 50th-street: Isaac Lawrence's summer seat. Here the rock projects into the river with cliff thirty-five feet high. Strike N 30° E. Dip vertical. Plenty of greenstone boulders in the valleys; gneiss of ordinary quality.

The rock from the vicinity of the shot tower, 52d-street to 79th-street, still on the banks of the river, is gneiss of an inferior quality. Strike N 40° to 45° E, and the dip 80° to 85° E, and from that to 80° or 85° W. Boulders of coarse greenstone, sandstone and granite.

79th-street: The rock on the banks projects in view. Strike N 40 to 45° E. Dip E 85 to 90°. Inferior gneiss, charged with pyrites or oxide of iron from the decomposition of the pyrites.

From 79th-street, or Blackwell's island ferry, to the 3d avenue, the whole rock is covered with drift, the rock only appearing here and there. Strike N 45 to 40° E. Dip mostly vertical, with drift grooves, averaging N 45° W.

79th to 82d-street, on the banks, strike on an average N 40° E. Dip 85 to 88°. Drift grooves abundant. Direction N 45° W. Boulders of greenstone in great abundance. Nine-tenths of the whole of these strata are perfectly straight for six hundred or eight hundred feet together.

82d to 86th-street: On the banks, rocks more generally covered with drift loam and gravel, except on the water's edge, but where visible observation gave for the strike N 40° E, and dip W 75 to 85°. The rock is only valuable for filling in.

86th-street: Hellgate ferry is situated at the foot of 86th-street, and is on the same street as the stopping place of the railroad cars at Yorkville. The rock does not appear above ground from Yorkville eastward, until within a few rods of the river, when it appears of a loose texture, columnar structure, abounding in iron pyrites so much, that in decomposition from exposure, copperas enough is produced to injure or destroy in many places the growth of vegetation; and in a dry time the copperas covers the ground, appearing like hoar-frost. Such was the condition of the rock when I first saw it on the 6th of September, 1838. The strike of the strata here is N 40° E, and the dip, though obscure, was 75 to 80°, and sometimes 85° E.

From this point, that is, from 86th-street to 94th-street, where we meet the marshes bor-

dering on Harlem creek, and which is connected with Harlem valley, the rock appears in place only on the banks of the river, and varies a few degrees only in strike or dip, and affording an average strike of N 40° E. Dip vertical.

North Part of the Island.

4th avenue terminates on Harlem river, at 133d-street, from which point I followed the river banks, keeping on the high ground to Kingsbridge, and returned by the great road from Harlem to Kingsbridge, which passes a little east of the middle division of the island.

As we follow up the southwestern shore of the river, the ground is low and marshy, and the Harlem flats extend to 142d-street, and west to 7th avenue. At this junction, about half a mile north-northwest of Harlem bridge, the gneiss first makes its appearance upon the surface. Strike N 25° E. Dip vertical, or 85° W in some places.

The rock is generally well stratified, fissile and tender, containing thin veins of granite, and in some places highly charged with iron rust; in others, hornblende so predominates as to cause the rock to assume the columnar structure. Sometimes mica occurs in so large laminæ, and black, as to give a showy exhibition.

On a line with 7th avenue, from Harlem village northward, and in direction north-northeast and south-southwest, there is a range of elevated ridge, two hundred to four hundred feet wide, and fifty to eighty feet above the river on the east and the valley of 8th avenue on the west, and extending northward to M'Comb's dam on the northern extremity of 8th avenue.

The rock of this ridge is so impregnated with iron pyrites, as almost entirely to prevent its profitable use as a building material where it is to be exposed to atmospheric agents. 7th avenue is not opened any where beyond Harlem.

The earthy covering of the ridge is fine drift loam, supporting good crops of grain and grass; and here and there boulders of greenstone, granite, and on its northern part abundance of white marble boulders. At this place, that is, near M'Comb's dam, the ridge is covered in many places from fifteen to twenty feet with drift loam, sand, gravel and pebbles, with large boulders in limestone or marble, which makes nearly one-third of the whole, the rest being greenstone like that of the palisades, and sandstone like that under them; and the marble precisely like that of Kingsbridge. Boulders of gneiss and granite were also found in considerable quantities, but angular and rough, while the others were generally rounded and smooth.

The gneiss here appears in place, cropping out in many places, full of granite veins, but well stratified in the main, and with here and there traces of carbonate of lime. Strike N 35° E. Dip nearly vertical.

The river and general course of the valley, for nearly two miles, and perhaps more, above this place, runs N 15 or 20° E, and from the materials, their position, and that of the valley together, the inference is strong that the materials here piled up have come from the Palisades, Kingsbridge, and the contiguous parts of the valley.

Crossing the creek west side of M'Comb's dam, examined the rock, which again appeared within one hundred rods northwest, about on the line with 9th avenue. Coarse, inferior gneiss, without veins. Strike N 35° E. Dip vertical.

162d-street at 10th avenue: On Madame Gemmel's place the rock appears on the surface, and is covered with grooves. Direction N 45° W. They are very distinct at the Porter's lodge, south side; also within the yard and enclosures. Strike N 30° E. Dip vertical.

Again about half a mile northward, at the ten-mile stone on the Kingsbridge road, a few rods north, and again a few rods south of the stone, drift grooves very numerous and distinct. Direction N 35° W. Strike N 30° E, and dip vertical.

186th, 187th and 188th streets: Still on the road, and west of 11th avenue and east of 12th avenue. Here are boulders of greenstone, granite and white marble, like that of Kingsbridge; the rock not seen in place at this spot. Here or a little south of the place, the island seems to divide longitudinally into the western and eastern ridge, elevated from sixty to one hundred feet above the Hudson and East rivers, or the contiguous waters, with an intervening valley extending to the village of Kingsbridge, and descending most of the way thither. The western ridge continues to the north end of the island, while the rock of the eastern dips down and disappears near 195th-street and 12th avenue, which is considerably east of Kingsbridge road.

From 195th to 197th-street, there is an opening through the western ridge, forming a continuous valley from the Hudson to the Spuytenduyvel creek (or East river where it approaches Kingsbridge). Through this valley, vast masses of drift in form of loam, sand and gravel, have been carried and piled up in conical hills east of the road, and on the northern slope of the eastern ridge, which also contains abundance of boulders of marble, granite, greenstone and sandstone.

At the northern part of this valley, and from thence to Kingsbridge, the road continues on the east of the ridge, and in view of the East river, leaving all the high grounds on the west. It is at this northern portion of the valley, and on the eastern portion of the ridge, that the limestone, called Nichol's quarry, begins, and continues to the northern extremity of the island, a distance of a mile or a mile and a quarter. Here the limestone has been opened for marble. The quarry belongs to a Mr. Thompson, who resides at Yonkers. Most of the material obtained from it hitherto has been used, and is now being used, to macadamize the roads in the vicinity. The marble is of two varieties, coarse granular white or yellowish white, and compact white or bluish. This quarry is the last opened in this neighborhood, about a year ago, and is forty to fifty feet deep on north side, and extends into the side hill about the same distance, and on a level with the bottom of the valley.

The marble is, taken as a whole, rather inferior; seems to be a part of the gneiss formation, with only a change in the mineral matter; for at the junction of the two, and often for a considerable distance in the marble, it continues the structure of gneiss; and this is almost always the case where the mineral matter of the gneiss commingles with the marble, but wherever the material becomes a pure limestone, it then lies in beds, almost without stratifi-

cation. The marble, as stated, commences at the valley (204th-street), where the lime mingles with gneiss; has a strike N 30° E; dip vertical. The limestone is from fifty to eighty yards in width, gneiss contiguous on either side, and at a distance of eighty or one hundred yards from the road. As it continues northward the limestone widens, following a line westward of, and nearly parallel with the road, but often appearing under the road, and on the eastern side of it, until it has widened to four hundred or six hundred yards; and after continuing northward from the valley above named about half a mile, the gneiss on the Hudson runs out, and the whole ridge becomes limestone nearly opposite to, or rather a little beyond Tubby hook, on the Hudson (Vide Pl. 30, fig. 7). The general direction of the strata is N 25 to 30° E, and dip E 60 to 75°, and occasionally vertical.

North of Mr. Dykeman's farm, which is about one mile from the northern extremity of the island, are situated a series of abandoned quarries of limestone, which have been successively wrought for lime and abandoned within the last thirty or forty years, not one of which, to my knowledge, is now wrought to any extent. The strike is on an average N 45° E, and dip 45° E, somewhat tortuous. The first of the abandoned quarries (the south) is six hundred to eight hundred feet north and south, or in the direction nearly northeast and south-west.

Again a few rods north of the old tide-mill, which is in a natural valley which interrupts the chain of hills constituting the limestone formation of the vicinity, and is represented on the sketch (Pl. 30, fig. 7), the limestone occurs, containing a stratification of gneiss, with a mixture of gneiss and limestone. Strike N 45° E. Dip E 45°. The rock is of an inferior quality, but withstands the elements well; and the same quality of rock seems to extend to the northern extremity of the island, but it has been very little wrought northward of the tide-mill; but from this point southward to near Mr. Dykeman's house, a distance of more than half a mile, and on the west side of the road, are found all of the abandoned quarries which were formerly wrought for burning into lime.

From the old tide-mill, on Nichols's canal, to the northern extremity of the island, the whole ridge narrows so much that it is not more than from one hundred to five hundred yards in width, and from ten to thirty yards in height.

The marble from Kingsbridge and its vicinity, is all of an inferior quality, from the fact that the grains composing it are possessed of so little cohesion that it disintegrates and falls to a calcareous sand. It has been called magnesian limestone, and I know of no analysis that has been made of it, but I think it desirable that in either case an analysis should be made. The rock contains pyrites to a considerable extent, so that after long exposure it becomes oxidized, and the whole is covered to such an extent as to give it a yellowish cast. It contains cross veins of white pyroxene.

228th-street is the northernmost street on the island.

Returning from Tubby hook to Manhattanville, or from 200th-street to 126th-street, on the west side of the island, we found comparatively few interesting geological facts to claim

especial notice. Drift grooves, generally vertical strata, with strike varying from due north to north 45° east. On the shore of the Hudson the rock is in view most of the distance, and generally precipitous.

Statistic and other Details.

Cost of building and other materials.

1. The market value of earth for filling up docks or streets, depends on circumstances, and varies accordingly from twelve to thirty cents per cubic yard. Average eighteen cents.

2. The same amount per cubic yard is also paid for excavations of earth, and removal of the same out of the way.

3. The market value of rough stone for basements, wharves, etc. is one dollar per load, which, for one horse, is nine cubic feet.

4. Stone in shape for curbstone, bears a price of forty cents per cubic foot.

5. Stones in shape for gutters are thirty cents per cubic foot. The materials of Nos. 4 and 5, were formerly brought from Connecticut, at a price of seventy cents per cubic foot, but within the last year they have been furnished from the mouth of the Rondout on the Hudson below Kingston, and the Connecticut stone is thrown out of the market.

6. The amount paid for excavating stone depends on the nature of the stone and the facilities for getting it out of the way, and varies from ninety to one hundred and ten cents per cubic yard.

The marble for the City Hall was obtained from West-Stockbridge, and was brought to Hudson thirty miles by land, and thence by water to this city.

The number of loads of manure sold by the Corporation, from September 1837, to September 1838, I have ascertained to be as follows:

September, 1837,	15,801
October "	11,326
November "	9,728
December "	8,242
January, 1838,	7,525
February "	730
March "	15,000
April "	26,328
May "	18,009
June "	16,392
July "	12,699
August "	15,349
	157,129

Refused matter, as sand and other useless sweepings of streets, seventy-five loads per day, or about twenty-two thousand loads per annum.

Average price per cartman's load for manure is twenty-nine cents (i. e. 1837–8.)

The expense in collecting it, in 1834, was $76,124.59; sales of the same, $30,279.59. In 1836, expense $109,218.79; sales, $41,836.68. In 1837, expense $157,307.15; sales of the same, $47,700.86.

Borings in different parts of the city.

1. Holt's well, between Pearl and Water streets, near Fulton market, extended one hundred and twenty-six feet before striking the rock, and continued into the rock five hundred feet further, making a total depth of six hundred and twenty-six feet; two and half inch hole, except the upper part of two hundred feet, three inch hole.

2. The old Rock well, near Trinity church, is twenty-six feet.

3. The Manhattan well, in Duane-street, near Centre, is thirty feet deep. Dug 1799.

4. The well at the corner of Bleecker and Broadway, is four hundred and forty-eight feet deep. The rock was reached at the depth of forty-two feet, and carried into the rock four hundred and six feet, with seven inch hole, yielding one hundred and twenty thousand gallons in twenty-four hours.

5. The well at the city reservoir, in 13th-street, is one hundred and thirteen feet deep, and seventeen feet in diameter; and the rock was reached at the depth of fifteen feet, and carried into the rock with two horizontal shafts at bottom, one a hundred and ten feet and the other seventy-five feet.

6. The well at the corner of Grand and Wooster streets is forty feet through filled in grounds; then twenty feet of mud, trees and vegetable matter, with drift; then six feet of fine blue clay; and then six feet of sand, like that found on the surface; making a total of seventy-two feet.

7. Well corner of Green and Thompson streets. ———

8. Well at Washington market, at Washington-street, between Vesey and Fulton, reached the rock at seventy feet.

9. Well at the corner of Factory and Perry streets; shaft seventy feet to the rock, and one hundred and thirty feet in rock.

10. On the same track, near 16th-street, the shaft twenty feet to the rock, and one hundred feet in rock.

11. Allaire's, Cherry-street at Corlear's hook, eighty feet in drift without reaching rock.

12. Well at the corner of 5th-street and Avenue D, shaft sunk to the rock at the depth of one hundred and nine feet.

13. Dry dock shaft one hundred and thirty feet to the rock, and then bored two hundred feet in the rock.

14. At the dairy establishment at Hoboken, four hundred feet; reached rock at forty feet; serpentine sandstone, and supposed white marble.

15. Well at the corner of Houston and Lewis streets, reached rock at ninety-four feet.

16. Corner of Avenue D and Houston-street, reached the rock at ninety-six feet.

17. Corner 7th-street and Lewis, reached the rock at ninety-three feet.

18. Corner of 7th-street and Avenue D, reached the rock at one hundred feet.

19. College place, reached the rock at eighty feet; all sand.

20. At Fulton market, one hundred and thirty feet.

21. Centre-street, Halls of Justice, forty feet filling in, thirty feet very soft black mud, then thirty feet blue clay.

22. Foot of Jefferson-street and East river, reached the rock at fifty feet; ten feet drift, and forty sand and clay.

23. Bored seventy feet to hard gravel at Williamsburgh, but without reaching the rock.*

228th-street is the northernmost street on the island. Twenty streets make one mile. The breadth is from half a mile to two miles and a quarter.

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* Most of the above facts, on wells and borings, are furnished by Mr. JOHN DISBROW, 136 Bowery.

CHAPTER X.

DIP AND STIKE OF ROCKS, AND GENERAL INFERENCES FROM THE FACTS IN THIS VOLUME.

In the preceding chapters of this volume, the rocks of the First geological district of the State of New-York have been described, as far as they have come under examination during the survey, and some observations made antecedent, by myself and others, have been introduced; but I have not been able to collect all the published observations of others, in consequence of not having access to all the works in which their observations have been recorded. I have endeavored to give credit to all, where credit was due, but am sensible of some important omissions; among which may be mentioned some of those of Dr. S. L. Mitchill, Dr. Akerly (*On the Geology of the Hudson*); Prof. A. Eaton (*Geology of the Northern States*); various articles, by sundry persons, in *Bruce's Mineralogical Journal*, *Annals Lyceum of Natural History of New-York*, *Journal of the Academy of Natural Sciences of Philadelphia*, *Memoirs of the Albany Institute*, *&c.*

There remain for consideration, various facts connected with

1. Axes of elevation, { Longitudinal, / Transverse. }
2. Fractures of the strata, *joints* and veins.
3. Ages of rocks, and periods of elevation and of metamorphic agency.
4. Cause that has led to all these disturbances, and changes of character.

1. *Axes of elevation.* Various isolated facts have been observed on this subject, some of which have been alluded to in various parts of this work; enough to demonstrate two main directions of elevation, transverse and nearly perpendicular to each other. The contortions of rocks, the metalliferous and other veins, the altered and modified rocks, etc., are found almost constantly associated with the axes of elevation, one of which ranges between north and northeast; and the other about west-northwest, or along joints and fractures, nearly parallel to these directions. The other directions of joints and lines of fracture and disturbance, although not uncommon, are less frequent.

The following table shows the strike and dip of the strata, as observed in various places in the First geological district. Some of them were estimated by the eye in their strike, not having a compass at all times; and the dip was always estimated by the eye, and both are considered as only approximations to the truth.

No.	Strike.	Dip.	Kind of rock.	LOCALITIES.
		KINGS COUNTY.		
1	NNE	90°	Gneissoid rocks	Near Astoria.
2	do	90°	Gneissoid rocks and hornblende	Hurlgate.
		NEW-YORK COUNTY.		
1	N 25° E	N 70° W	Gneiss, micaceous...	At corner of Third avenue and 50th-street, covered with drift scratches. The strata for some distance north and south of this, dip to the N and NW from 30° to 80°; but at 77th-street the rock resumes its usual dip to the ESE.
2	NNE	Vertical	Gneiss, micaceous; also hornblendic, with beds and veins of granite.	Hurlgate ferry, at the east end of 86th-street.
3	NNE	Variable	Gneiss, mica slate, etc.....	From the city to the north end of the island. The strike and dip are indicated in various parts of the island, on the map of the island on Pl. 1, fig. 2.
4	N 20° to 30° E.	ESE 30° to 60°	Gneiss	Blackwell's island.
5	do ..	do	Gneiss and hornblendic gneiss	At Hurlgate.
6	N 30° E; varies from this to N	.....	Anthophyllite rock and gneiss	From 59th-street to 63d-street, and between Tenth avenue and the Hudson.
7	N 30° E	Vertical	Gneiss	On the shore of the Hudson opposite the Orphan Asylum.
8	do	do	Gneiss abounding in quartz veins, and covered with drift scratches; N 30° W.	On the shore of the Hudson at 75th and 77th streets.
9	N 20° E.....	do	Gneiss	Between the Bloomingdale road and Hudson river. Vide Pl. 37, fig. 2.
10	N 35° E	Westward 50° to 80° .	do	At the quarry opposite Burnham's hotel.
11	N 25° E	Vertical	.....	At No. 4, on Pl. 37, fig. 2, of drift scratches.
12	.....	W 80°	Gneiss covered with drift scratches	From J. K. Howland's country seat, 600 or 800 yards north.
13	N 30° E	Westward 80° to 85° .	Gneiss with veins of granite	On Eighth avenue and 28th-street.
14	N 10° E	do 85° to 90° .	Gneiss and granite workable for common purposes	do and 36th-street.
15	N 8° to 10° E .	do 85°	Gneiss, tortuous	do and 38th-street, on east side of avenue it has been quarried.
16	N and S	W 75°	Gneiss	25 rods east of the last.
17	....	.....	Granite bed, above grading 175 feet E and W, and 410 feet N and S	On Eighth avenue and 41st and 42d-streets.
18	N 20° E	Westward 80° to 85° .	Gneiss, fissile	do and 50th street.
19	N 30° E	do 60°	Gneiss.....	do and 54th and 55th-streets.
20	do	Vertical	neiss covered with drift grooves	do and 58th street, on the east side of the avenue and west side of the Bloomingdale road near the junction.
21	do	do	Gneiss covered with drift scratches and granite veins	Near the junction of the road and avenue, northwest from it 100 yards, and northeast from it the grooves cover almost the whole surface. Grooves N 45° W.
22	do	do	Gneiss and grooves	Near Mr. Howland's residence.
23	N 40° E	do	do do	A few rods south of the six-mile stone.
24	N 30° to 35° E.	do	do do	Near Mr. Francis, north of the sixth milestone, corresponding to 96th-street.
25	N 35° E	Westward 80°	do do	Near Mr. Darkes, on the east side of the Bloomingdale road.
26	do	Vertical	do do	Bloomingdale road and 109th-street.
27	do	.....	do do	East and west side of Bloomingdale road near Lunatic Asylum.
28	N 30° E	Eastward 85° to 90° ..	do do	By the lane leading to the Lunatic Asylum.
29	N 25° to 30° E.	....	Gneiss and drift scratches	Bloomingdale road and 116th-street.
30	N 25° E	N 65°, W. 85°	do do	In the first battery or redoubt south of Manhattanville.

No.	Strike.	Dip.	Kind of rock.	LOCALITIES.
31	N 25° E	Vertical	Gneiss and drift scratches	In the second battery, 200 or 300 yards east of the last.
32	do	Westward 80°	do do	In the third battery southeast of the preceding.
33	do	do	do do	In the fourth battery southeast of the last. This is on a promontory stretching into the valley, and on which the Croton aqueduct has been brought into the city.
34	N 30° E	Eastward 80° to 85° ..	do do	On hill on the Eighth avenue.
35	do	Vertical	do do	At 97th-street and 80th to 98th-street near the rail-road track.
36	do	do	do do	At 96th to 95th-street, east side of track.
37	do	do	do do	At 95th to 94th-street, do do
38	do	do	do do	At 93rd to 92nd-street, do do
39	do	S 60°, E 75°	do do	About 20 rods south of the last.
40	N 25° E	Vertical	do do	At 86th-street.
41	do	do	do do	At 84th-street.
42	do	do	Gneiss and drift scratches full of veins and very tortuous	At 84th to 82nd-street.
43	do	Westward 80°	Gneiss in a state of rapid disintegration	At 76th to 75th-street.
44	N 35° E	.....	.....	East side of 68th-street to 69th-street.
45	N 30° E	Vertical	Gneiss not sound enough for working	West side of 67th-street to 66th-street.
46	N 35° E	.....	Gneiss fast disintegrating..	do 66th-street to 64th-street.
47	N 20° E	Westward 45° to 50° .	Gneiss with large veins of granite	Seventh avenue, 24th-street.
48	do	Westward 80°	Gneiss, ferruginous	Sixth avenue, 32nd-street.
49	N 15° E	do	Gneiss, sound and full of quartz veins.	do 29th-street.
50	N 30° E	Westward 75°	Gneiss	do 20th-street.
51	N 20° E	do 80°	Gneiss abounding in tortuous granite veins, and covered by drift grooves	Fifth avenue, 33rd-street.
52	N 25° E	do 80°	Gneiss	Corner of Fourth avenue and 16th-street.
53	N 30° E	do 75°	Gneiss and drift grooves ..	Twenty-five rods west of Fourth avenue and 25th-street.
54	N 25° E	do 80° to 45° .	do	Railroad cut, where horses are replaced by steam, 32d to 37th-street.
55	do	do 45°	do	53d-street, on railroad line.
56	N 45° E	do 45° to 80° .	do	79th-street to the tunnel; strata much confused in the southern part of this space.
57	do	do 45°	Gneiss, disintegrating from containing pyrites	120th-street, railroad line.
58	do	W 45°, W 80°	Gneiss	On the railroad at 129th-street.
59	N 25° E	Westward 70° to 80° .	do	On Third avenue at 104th and 105th-streets, near Harlem creek (not Harlem river).
60	do	Nearly vertical	do	On Third avenue from 105th to 94th-street; in many places on the east side.
61	do	Average vertical	do	On Third avenue, from 94th to 79th-street, on east and west sides.
62	N 30° E	Westward 45°	Gneiss covered with remarkable drift grooves, N 25° W	On Third avenue, between 49th and 50th-streets, ten rods east and one rod west of the avenue.
63	do	do 75°	do do	On 47th-street, thirty rods east of Third avenue.
64	N 25° E	do 45 to vertical and 45° E.....	Gneiss	From 79th to 44th-street rock emerges generally on the top of the knolls.
65	N 30° E	Westward 75°	do	At 43d-street grooves on both sides of the avenue N 25° W.
66	N 45° E	do 35° to 40° .	do	On Third avenue, from 42d to 44th-street.
67	do	do 45°	do	do from 34th to 35th-street.
68	N 40° E	do 80°	do with drift grooves, N 25° W	On Second avenue, east side and 16th-street.
69	N 35° E	do 80°	Gneiss	On Third avenue, do do
70	N 25° E	do 80°	do	On Fourth avenue, do do
71	N 35° E	do 75° to 80° .	Gneiss and drift grooves ..	Between Third avenue and East river at 22d-street.

No.	Strike.	Dip.	Kind of rock.	LOCALITIES.
72	N 25° E	Westward 50° to 80° .	Gneiss, fissile and decomposing	Along the north end of Bellevue enclosure.
73	N 30° E	do .. 45°	Gneiss with few veins covered with drift scratches	First avenue and 35th-street on shore.
74	N 45° E	do 45° to 50° .	Gneiss	Mott's quarry near 37th-street and First avenue.
75	N 30° E	Vertical	do	48th to 50th-street, cliffs on the shore.
76	N 40° to 45° E.	Varies from eastward 80° to 85° to westward 80° to 85°	Gneiss, inferior quality	From the Shot tower to 79th-street.
77	do do .	ESE 80° to 90°	Gneiss containing pyrites or oxide of iron	On the shore at 79th-street.
78	do do .	Vertical	Gneiss with grooves, N 45° W	From 79th-street to Third avenue, where the rocks are visible.
79	N 40° E	SE 85° to 88°.....	do do	From 79th to 82d-street.
80	do	SW 75° to 85°	Gneiss	From 82d to 86th-street along shore.
81	do	S 50°, E 75° to 80° and 85°	Gneiss, pyritous	Hurlgate ferry, 86th-street.
82	do	Vertical as an average.	do	Along the shore from 86th to 94th-street, where the rock is exposed.
83	N 25° E	Vertical, 88° westward in some places	Gneiss	½ NNW of Harlem bridge on the shore at intersection of 142d-street and Seventh avenue.
84	N 35° E	Nearly vertical	Gneiss traversed by numerous granite veins	Ridge on a line with Seventh avenue, and extending north-northeast towards M'Comb's dam.
85	do	Vertical	Gneiss without any veins..	On a line with the Ninth avenue, 100 rods northwest of M'Comb's dam.
86	N 30° E	do	Gneiss covered with drift grooves	At Tenth avenue and 162d-street, on Madame Gemmel's place.
87	do	do	do do	About half a mile northward, at the tenth milestone on the Kingsbridge road.
88	do	do	Gneissoid limestone	In the valley at 204th-street.
89	N 25° to 30° E.	Eastward 60° to 75° ..	Limestone	Nearly opposite, or a little beyond Tubby hook on the Hudson.
90	N 45° E	SE 45°, tortuous	do	Old abandoned quarries about a mile from the north end of New-York island.
	do	do do	do	A few rods north of the old tide mill.
91	.....	....	Gneiss with large veins of coarse granite	On Tenth avenue ridge, forty or fifty feet high between 32d and 37th-streets.
92	Very confused .	About vertical	Gneiss and granite mixed in great confusion	On Tenth avenue between 42d and 44th-street.
93	....	.....	Mostly granite, a few thin strata of gneiss, sound and workable but rather coarse	On Tenth avenue, between 44th and 48th-streets and across Eleventh avenue to the river.
94	.....	.....	Gneiss with large veins of granite ten to twenty feet wide, of good quality for building	On Tenth avenue, between 48th and 50th-streets.
95	NW and SE ..	NE 85°	Gneiss, ...	On Ninth avenue and 29th-street.
96	do do ..	.....	Gneiss, ten feet above grading, and extends 200 feet and disappears under the soil. Strata contorted with veins of quartz and granite in every direction	On Ninth avenue and 36th-street.
97	N 1° to 10° E .	W 75°.....	Gneiss with veins of quartz	On Ninth avenue and 42d-street.
98	N 20° to 30° E.	N 70° to 60°, W 70° to 80°	Gneiss, with veins of coarse granite	Between Ninth and Tenth avenues rock emerges 400 feet north and south, and 150 feet east and west.
99	N 15° to 20° E.	Vertical	Gneiss with granite veins..	On Ninth avenue, and 52d and 53d-streets.
100	N 30° E	N 60° W 80°	Gneiss	do do 56th and 57th-streets.
101	N 10° W	Vertical	do	On Tenth avenue, and 63d to 64th-street.
102	N 30° E	N 60° W 80°.....	do with veins of granite	do do 63d-street.
103	do	Vertical	Gneiss confused by the intrusion of granite	do do 67th-street.
104	N and S	W 80°.....	Gneiss full of granite veins, disintegrating	do do 68th and 69th-streets.
105	N 30° E	Vertical.....	Gneiss covered with drift scratches, N 35° W	do do 70th-street.

No.	Strike.	Dip.	Kind of rock.	LOCALITIES.
106	N 35° E	.....	Gneiss with granite veins..	From Tenth to Eleventh avenue on 70th-street.
107	N 10° E	N 80°, W 85° to 90°..	Gneiss	From Eleventh avenue to river on 70th-street.
108	N 30° E	Vertical	Gneiss with granite veins three to ten feet wide, and quartz veins one to four feet wide.	On the shore of the Hudson at 70th-street.
			WESTCHESTER COUNTY.	
1	N 25° E	N 70° W	Gneiss	New-Rochelle.
2	N 25° to 30° E.	WNW 60° to 80°....	Gneiss, hornblendic gneiss, hornblendic slate, mica slate, etc.	Between Byram river and New-York, along the coast.
3	do do .	WNW 80°	Micaceous limestone having the general aspect of gneiss	Northeast of Harlem, half a mile.
4	Northward	Westward 80°.	Gneiss, mica slate, and limestone.	Between Tarrytown and Whiteplains.
5	N and S	West 50°	Grey limestone	Two and a half miles west-northwest of Whiteplains, at Elijah Martin's quarry.
6	do	do	Mica slate, east and west of the above limestone	A few rods west of the above quarry by the roadside, also a quarter of a mile east.
7	N 32° E	Westward 80° to 90° .	White marble.....	Kane and Morgan's quarry.
8	do	do do .	Micaceous gneiss	Bounding the above marble east and west, ranging northward west of Whiteplains.
9	N 20° to 36° E.	Sometimes eastward and sometimes westward	Gneiss, limestone, and mica slate	Between Phillipsburgh and Whiteplains.
10	do do .	do do	do do	Generally through Westchester county, with many local exceptions.
11	NE	NW 70°	Limestone	One mile west of Whiteplains.
12	N 30° E	N 60°, W 80°	Gneiss	Valentine's quarry, two miles east of Yonkers.
13	do	Nearly vertical	White limestone	Mathew's marble quarry, Westchester.
14	do	N 60°, W 60° to 80° .	Gneiss	From Whiteplains to Bedford, by the northeast corner of Northcastle, the valley of the Bronx and Byram pond.
15	do	N 60°, W 80°	White limestone and gneiss alternating (Cassels)	Near Mr. Knapp's house near Cross pond, Poundridge.
16	N 70° E	N 30°, W 60°	Limestone with gneiss on each side	Between Long and South ponds, Salem.
17	N 20° E	.....	Gneiss covered with drift scratches (Cassels)	About two miles southeast of Verplanck's point, on the postroad, Cortland.
18	NNE	Vertical	Limestone and hornblende slate and veins of trap	At Verplanck's point (Cassels).
19	E and W	.....	White and grey limestone .	On H. I. Cruger's farm, Cortland.
20	N and S	.....	do do .	On H. I. Cruger's farm, south of the preceding.
21	N 70° E	S 20°, E 80°	Gneiss very slaty	At the coal mine at Peekskill landing. Carbonaceous matter as thick as coats of varnish through about four feet of rock. Two veins of matter about four to ten inches thick, something like plumbago (Cassels).
22	Easterly	Southerly 80°.....	Gneiss used as a quarry stone	Solomon Rundle's quarry near the upper dock, Peekskill.
23	NNE	ESE 30° to 40°	Gneiss, with some granite veins and interstratified masses	Van Cortland's quarry, northwest of Roya point.
24	Eastwardly....	Vertical and contorted	Micaceous limestone.....	Half a mile east of Peekskill, on the hill not far from the academy.
25	N 30° E	S 60° E	Limestone (white) used for burning lime	On Mr. Miller's farm near Mill creek; the outlet of Crum pond, three miles south-southeast of Crumpond village.
26	N 20° E	Vertical	Limestone and altered rocks	"Copper mine" near Sparta, Mount-Pleasant.
27	N 22° E	About S 58°, E 45° ..	Limestone lying on granite	On the north side of the point at Sparta, Mount-Pleasant.

No.	Strike.	Dip.	Kind of rock.	LOCALITIES.
28	.....	Eastward 60° to 70° ..	Limestone lying on granite	Thirty rods eastward of the preceding.
29	N 20° E	Vertical	.....	A few rods north of the last.
30	Eastward and westward	Southward	Gneiss, mica slate, augite, etc.	Murray mountain at Sparta. This transverse stratification is opposite the great trap dyke, on the west side of the bay, near Verdrietje hook.
31	Northwardly, angle not taken	Vertical	Limestone and mixtures of this and augite, magnetic pyrites, etc.	At the old "silver mine" on the shore between the State prison and Singsing landing.
32	NNE	ESE 70°	Talcy slate	On the postroad near Peekskill creek, and Blue-rock point.
33	do	do 60° to 80°	Slaty limestone	South of Annville, across the marsh.
34	do	do 70°	Talcy slate	Gallows hill.
35	do	do 70°	Various rocks	Roya hook to Peekskill. Vide Pl. 14, fig. 4.
36	do	WSW 20° to 30°	Hornblendic, sometimes stratified	Between Peekskill and point below.
37	do	Eastward and westward	Various rocks	Synclinal and anticlinal axis, between Verplanck and the Croton. Vide Pl. 14, fig. 7.
38	do	Nearly vertical	Gneiss and hornblendic gneiss, with veins and beds of granite	Ridge north and northwest of Tarrytown and Mrs. Beekman's quarry.
39	do	do	Gneiss, hornblendic gneiss, and limestone, with veins and beds of granite	Along the shore, in numerous localities, from Tarrytown to Yonkers.
40	W 80° to 90° ..	W 80° to 90°		

PUTNAM COUNTY.

1	NNE	ESE 30° to 80°	Gneiss, hornblendic gneiss, (with veins and beds of granite, magnetic iron ore,) limestone, etc.	Generally throughout the county, with some local exceptions.
2	N 40° W	N 50°, E 50°	Thick bedded gneiss	On the shore of the Hudson near Peekskill. Vide courses 2 and 3, on table, p. 544.
3	.....	SSE 60°	Granular quartz	do do do do
4	.....	Nearly vertical	Hornblendic gneiss	Point about west of a small island near the left bank of the Hudson, in the Horserace, between Peekskill and Anthony's-nose point. Vide table, on page 544: No. 9.
5	.....	Vertical	Gneiss, feldspathic gneiss, and hornblendic gneiss	Vide table, on page 544: No. 14.
6	NNE in some places, NNW in others	Vertical and variable in some places ENE 30°	Granite gneiss and hornblendic gneiss	do do No. 15.
7	NE	Nearly vertical strata .	Hornblendic gneiss, granite gneiss, etc.	Two rocky islands, above Anthony's-nose point, in front of the salt marsh on the left bank of the Hudson. Vide No. 21, p. 545.
8	Northeasterly ..	Eastward 60° to 90° ..	Serpentine, limestone, augite, pyritous gneiss, etc.	On the promontory on which the "old silver mine" is located. Vide No. 23 to 28, on page 545.
9	NW	.....	Gneissoid and hornblendic gneiss rock	At the mine of arsenical iron, three miles northwest of Putnam court-house. Carmel, near the bed of black serpentine and diallage.
10	N 30° E	ESE 30° to 80°	Gneiss of various qualities .	Putnam court-house to three miles northwest and north and northeast, is the usual strike and dip.
11	NNE	ESE	Limestone, containing augite, coccolite and brucite, bounded by gneiss	One and a half mile south of Putnam court-house, at two old mine holes.
12	NNE	Westward 40° to 60°?	Gneiss, containing pyrites, and traversed in northwest and southeast direction by quartz veins	At the locality where a lead mine is said to have been found many years ago and lost. Near the Croton river, south of Simewog mountain, on Jedediah Wood's farm.
13	NNE?	ESE 70° to 85°	Gneiss and hornblendic gneiss	On Simewog hill or mountain, at and near the iron mine.
14	N 30° W	.....	Serpentine, anthophyllite, talc, etc., in gneiss	At the "soapstone bed," near Peckville, one-half mile northeast.
15	N 30° E	.....	White and grey limestone containing tremolite	Two and a half miles southwest of Patterson.

No.	Strike.	Dip.	Kind of rock.	LOCALITIES.
16	NNE?	Nearly vertical eastward	Gneiss and limestone with other rocks, granite, augite, hornblende, etc.	From Putnam court-house to Patterson, and back, via the Croton river and Doansville.
17	NNE, N 20° to 30° E	ESE 60° to vertical ..	The gneiss and hornblendic rocks, and the magnetic iron ore of the Phillips vein	Phillipstown, at Phillips mines, and the various mines on that vein. Vide pages 561 to 565, of this volume.
18	do	WNW 70°	do do	Stewart's mine, on the above vein.
19	About NNE ..	Vertical	Limestone of the same range as that of Annville, in Westchester county	Three-quarters of a mile south of Bonnel's forge.
20	NNE	do	Limestone, verd antique, etc.	Hustis's quarry, Phillipstown, five miles from Coldsprings, and one-fourth mile east of the postroad.
21	Northeasterly ..	do	Gneiss, hornblendic gneiss and granite	At the point, at Coldsprings.
22	NW	Confused, in some places high	Gneiss, hornblendic gneiss, granite, sienite	Constitution Island, opposite West-Point.
23	NNE	ESE 40° to 90°	Gneiss, pyritous gneiss, augite	From Gouverneur's cove to Mine point, on the left Bank of the Hudson, Phillipstown.
24	do	ESE, high angle, often vertical	Gneiss, with beds of granite, augite, hornblende, limestone, serpentine, and diallage	"Mine point" to "Cotton rock," on the left bank of the Hudson, Phillipstown.
25	NW	.....	Limestone, colored with serpentine, and containing plumbago: and a bed of grey augite is on the north	Twenty to forty rods north of Beverly dock, Phillipstown.
26	NNE	Eastward, often vertical	Gneiss, granite, augite, limestone, garnet rock, etc.	From "Cotton rock" to Serpentine point, and on to Anthony's-nose point.
27	.....	Eastward, high angle .	Granular quartz, slaty	Peekskill hollow, near Bradley's ore beds, ten miles northeast of Peekskill.
28	N 30° E	Eastward?	Gneiss	Jared Crane's quarry, two and a half miles northwest of Somerstown plains (Cassels).
29	N 60° E	do	do	Between Mahopack pond and a small pond east of it, in the road.
30	N 40° E	.....	Felspathic gneiss	Howard's quarry, on Breakneck mountain, near Anthony's-face point.
31	N 46° E	North, 10° or 12° west	Gneiss, thick bedded and obliquely laminated	Phillips's quarry east of West-Point.
32	N 35° E	Vertical	Limestone containing grains of magnetic oxide of iron	In the road east of the Phillips Manor-house, and west of the mill.

DUTCHESS COUNTY.

1	NNE	ESE 10° to 15°	Grit, called greywacke ...	Fishkill, three-quarters of a mile from the village, on postroad.
2	.....	Nearly vertical	Grit and slate	At Wappinger's creek, at the crossing of postroad.
3	NNE	ESE 10° to 20°	Limestone	On the postroad one mile north of the above locality.
4	NNE to N	ESE 8° to 10° to 90°	Grits, slates, and slaty grits	Between Rhinebeck and Redhook.
5	WNW*	NNE		
6	.....	Nearly horizontal	Whitish limestone	Two and a half to three miles north of Amenia.
7	Northward	Slightly westward	Limestone	One-half mile west of the preceding.
8	Eastward and westward	Slightly northward ...	do	Three and a half or four miles west of the preceding.
9	Northward	Eastward high angle..	do	On east side of the above valley.
10	Northward and range east of the Indian pond ore bed	do do	Slate and limestone at their junction	On east side of the outlet of Indian pond. Vide Pl. 38, fig. 6.
11	Northward	Eastward 60° or 70° ..	White limestone, mica slate and limonite	Indian pond ore bed, edge of Connecticut near Dutchess. Vide Pl. 23, fig. 1.
12	do	do do	Mica slate	Mountain north of Leedsvllle.
13	do	Eastward 30° to 45° ..	Mica and talcy slate	Amenia ore bed, near village. Vide Pl. 23, fig. 2.

* Had no compass at that time, and may have erred as to strike and dip.

No.	Strike.	Dip.	Kind of rock.	LOCALITIES.
14	Northward	Eastward nearly vertical	Limestone (white), and mica slate containing garnets, etc.	Near Amenia furnace.
15	do	Eastward 60° to 70° ..	White limestone	Between Leedsville and Hitchcock's corners.
16	do	do do ..	Granular quartz.....	Southeast of Kline's corners.
17	N 10° E	N 80°, W 85°	Mica slate	The mountain, from west of Amenia to the Amenia furnace (Merrick).
18	N 45° W.....	High angle, direction not stated	do	Mountain west of Amenia furnace (Cassels).
19	N 30° E	Eastward	Sparry limestone	Near one-half mile north of Lithgow, near the Episcopal church (Cassels).
20	.....	Horizontal and slightly inclined	Limestone and mica talc slate	Between the Chalk-pond ore bed and Perry's corner.
21	N and S nearly	Eastward 60° to 90° ..	Limestone and mica slate ..	Dover valley.
22	N and S bearing a little east	Eastward, high angle .	Gneiss, micaceous gneiss, and granitic rocks, like those of the Highlands	Along east line of New-York, between Kline's corners and Kent's furnace.
23	do do	do do .	Mica slate and white limestone	Mountain between Leedsville and Amenia. Vide Pl. 23, fig. 3.
24	do do	Westward 10° to 40° .	Mica slate, decomposing, from containing pyrites	At the Alum rock, on the mountain southwest of Amenia.
25	Northward	Eastwardly, high angle	Blue limestone	At west base of the mountain, between city and Pineplains (Cassels).
26	N 15° to 10° E.	Westward 70 to 90° ..	Gneiss, hornblendic gneiss, etc., like the rocks of the Highlands	Mount Stessing southwest of Pineplains.
27	Northward	Eastward, high angle .	Mica and talc slate, and limestone	Winchell's mountain between Pineplains and Pulver's corners.
28	do	do do .	do do	Between Pulver's corners and Spencer's corners.
29	do	do 30° or 40° .	Mica slate containing garnets, staurotide and pyrites	Near the Salisbury ore bed, Connecticut, near Dutchess county.
30	NNE	ESE, high angle	Slate covered with drift scratches on the steep sides, as well as on the slightly inclined	On the south side of the Chicomeco valley, on the road from Pineplains to Ancram furnace.
31	S 70° W ?	Eastward 60° to 70° ..	Slate and limestone.....	At and near the Ancram lead mine. Vide Pl. 23. fig. 4.
32	Northward	Westward slightly,	Slate and limestone at their junction	One-quarter of a mile southeast of Pulver's corners.
33	do	Nearly horizontal	Quartz rock, stratified	Between Attlebury and Coldsprings, south end of Mount Stessing.
34	Nearly north	Eastward 40° to 60° ..	Grits, slates, etc.	Generally along the shore of the Hudson and in the interior, but local variations are numerous.
35	do ..	do do ..	do do	Islands south of Redhook.
36	NW	SW 30°	Barnegat limestone	At Barnegat, west of the Kilns.
37	NE	SE 30°	do do	One-half mile north of Barnegat.
38	NNE	ESE 80° to 90°	Slate and slaty limestone, containing shells like those of the Trenton limestone	One and a half or one and three-quarter miles north of Barnegat, on the shore of the Hudson. Strike and dip very variable about Barnegat.
39	.....	Very variable in strike and dip. Great derangements and contortions.	Slates, grits, slaty grits, etc.	Near Rhinebeck landing and Lower Redhook, and also about Thompson's landing.
40	N 50° E	S 60° to 70° E	Granite and gneiss, bounded by red and green slates and limestone	Lewis's landing.
41	N 45° to 60° E	S 60 to 80° E	Gneiss, hornblendic gneiss, etc.	Fishkill mountains east and southeast of Stormville.
42	N to E.....	Vertical	White limestone	One mile west of Poughquaick.
43	N and S	E 75°	Barnegat limestone	At Bockee's and Bryan's lead mines, veins fill joints in rocks of eastern and western directions.
44	Northward	Westward 15° to 20° .	Limestone (low ridge)	One mile south of Milan, near the "Christian" meeting house.

No.	Strike.	Dip.	Kind of rock.	LOCALITIES.
			COLUMBIA COUNTY.	
1	E and W	Vertical.....	Sparry limestone interstratified with slate	One-quarter of a mile east of Milan (Cassels).
2	do	do	do do	Four miles northeast of Milan, near Shufelt's tavern.
3	N 10° E	.....	Slate hills crossed by the Kinderhook and Hudson road, two miles from Kinderhook to the Upper falls.	
4	N 10° to 20° W	N 70° to 80° E and from 10° to 40° Eastward	Slates, grits, limestones, conglomerates, etc. Vide Pl. 24, figs. 2 and 3.	On the west side of Great Neuten hook, opposite Coxsackie.
5	N 20° W	N 70°, E 60° to 70°...		
6	E and W	Vertical.....	Slate	A little north of Mount Bob.
7	NW	NE 45°	Sparry limestone, contorted. Vide Pl. 38, fig. 2.	
8	do	NE contorted	Slate, containing graptolites and trilobiles	At the Lower falls of Kinderhook creek.
9	North	E high angle	Grit, succeeded on the east by red, purple, and variegated slates	One mile northeast of Rider's mills, in Chatham.
10	N 30° to 40° E.	SE 30°	Talcy limestone.....	Lebanon springs. p. 3, 183.
11	do do .	SE 40° to 60°.....	Talcy slate	A little east of Lebanon springs. p. 187.
12	.....	Eastwardly	Slates of various qualities .	Hancock mountain from Lebanon springs to the summit. p. 189.
13	N 30° to 40° E.	SE 30° to 40°.....	Roof slate quarries.....	Gillett & Co's. quarries, one and a half mile west of Lebanon springs. p. 192.
14	Northward	Eastward	Limestone intersected by veins of quartz	Between Lebanon springs and the Shaker village.
15	do	do	Limestone across the Lebanon valley	Lebanon valley, a little north of Whiting's pond. p. 3, 201.
16	N and S	Nearly vertical	Limestone in echelon ridges, general range, north-northeast and south-southwest. Vide Pl. 23, fig. 6.	West of Ghent. p. 3, 215.
17	Northward	Eastward high angle..	Slate, talcy slate, limestone, etc. Vide Pl. 14, fig. 1.	Hillsdale, east over the mountain.
18	do	do do ..	Same rocks.....	Four or five miles north of last section. p. 223.
19	do	Eastward about 30° ..	Red, purple, grey, etc slate, intersected in every direction by quartz veins	One-quarter of a mile from Canaan centre railroad cut.
20	NW and SE ..	.....	Ridge of slaty rock injected with quartz in every direction, almost trappean in aspect	One-half mile south of Canaan centre. p. 249.
21	.....	Eastward	Siliceous, slaty, injected rock. Pl. 23, fig. 7.	One-half to three-quarters of a mile south of Redhook. p. 255.
22	NW and SE ..	NE	Limestone	In the valley north of Hillsdale, from ——— mills to the Baptist meeting house. p. 263.
23	NW	NE 30° to 60°	Roof slate containing crystals of iron pyrites	Foster's slate quarries, Hillsdale.
24	SSE and NNW	ENE	Sparry limestone	Between Hillsdale and Mount Washington (Cassels).
25	NNE to SSW .	Nearly vertical, 60° to 90° eastward	Talcy and mica slate.....	Base of Mount Washington, and at Taghkanic falls (Cassels).
26	Northwardly ..	Eastwardly	Roof slate and sparry limestone	West side of Copake flats, and on the mountain side of Copake (Cassels).
27	do ..	do	Granular limestone	On the west side of Prescott's ore bed north of Hillsdale (Cassels).
28	do ..	Eastwardly slightly ..	Grit and blue limestone ...	Near Chrisler's pond, Copake.
29	NE	NW 10° to 15°	Slate	Near Montross on the Ancram creek. Variation local.
30	N 20° to 10° W	N 70° to 80°, E 15° ..	Slate, laminated and stratified. Pl. 10, fig. 5.	Near Jackson's corners.
31	Various	Very various in direction and amount	Grits, slates, and limestones of the Champlain division	Great Neuten hook; stratification contorted and broken up.

No.	Strike.	Dip.	Kind of rock.	LOCALITIES.
32	Various, E and W, N and S	Various, but northward and eastward	Grits, slates, and limestones of the Champlain division	Great Neuten hook.
33	do do	do do	do do	Stockport landing.
34	NNW, variable	ENE 10° to 50°, variable	do do	Between Hudson and Kinderhook.
35	.....	SE 2° to 10°	Helderberg limestone	Becraft's mountain, on the west side.
36	.....	SE or ESE.....	do do	Becraft's mountain near the road, by the milestone, in the field.
37	Northward	Eastward 10° to 20° ..	do do	Mount Bob, three miles north or northeast of Becraft's mountain.
38	.....	S to E, high angle ...	Slate containing graptolites	At the coal mine, from three-quarters to a mile south of Hudson.
39	S 30° W	S 60° E	Slate of Champlain division	One and one-eighth of a mile from Hudson, at the west base of Becraft's mountain.
40	do	South, high angle east	Slate and basanite and siliceous slate, black, blue, red and green	Blue hill three miles southwest of Becraft's mountain.
41	N 10° W	N 80° E	Limestone interstratified with slate	South end of Blue hill, on the road to Oak hill ferry.
42	N 20° E	ESE 70° to 80°	Limestone of the same stratum	On the farm of E. H. Plass, Greenport.
43	N to E	S to E 30° to 40°.....	Rock like a trappean rock, perhaps greenstone	At the lead mine on E. H. Plass's farm.
44	N 20° E	S to E 45° to 90°.....	Limestone interstratified with slate	East base of Merino mountain, one and a half mile from the tavern at the north end of the mountain, on the river road.
45	About NNE ..	W 70°; W about 15°; S 20° E	Helderberg limestone, slate of Champlain division	One-quarter of a mile south of Mr. M'Clellan's on the east side of Becraft's mountain, nearly in contact.
46	North	Eastward 80°	Overturned and reversed strata of limestone	Towards southeast part of Becraft's mountain.
47	NW	NE 15°	Striped calcareous slate....	Near northeast part of Merino mountain, near the tavern, south-southwest of Hudson.
48	.....	Vertical	do do	North end of Merino mountain, west of above.
49	.....	Eastward 30° to 40° ..	Brecciated limestone	On the road from Hudson to Oak-hill ferry, along the east part of Merino mountain.
50	N 20° W	N 70°, E 60° to 90° ..	Brecciated limestone, slates and grits	Various localities from Hudson, by Columbiaville, Stuyvesant's falls, Glenn, Cady, and to Kinderhook.
51	do	N 70°, E 25° to 50° ..	Slaty limestone in strata of slate	At the quarries east of Kinderhook lake.
52	do	W 25° to 80°	Slate and grits	One mile west of Kinderhook lake.
53	N 20° E; N 20° W ?	N of E ? high angle, variable, 40° to 90°, and contorted	Slate and siliceous slate grits	Valatie, in bed of the Valatie kill at the factory, and below the bridge, and along the banks of Kinderhook creek.
54	Northerly	Vertical.....	Slate and limestone interstratified	Malden village.
55	do	do	do do	Rider's mills.
56	N 10° E to N 20° W	Eastwardly 35° to 80°	Slates, grits and limestones	Many localities in Kinderhook and Stuyvesant, between Kinderhook and Schodack.
57	N 10° E ? or N 10 W	Eastwardly high angle	Fucoidal or graptolitic slate, with grits and slates	On the shore of Hudson, north of the brick kilns, near the northwest corner of the county.
58	N 10° W	N 80°, E 30° to 45° ..	Various rocks of the Champlain division. Vide Plate 23, fig 8.	Stuyvesant, near the northwest corner of the county.
59	NNE	ESE 50° to 90°	Grits, slates, slaty grits, etc.	Rogers' island, between Hudson and Catskill.
60	Very variable ..	Very variable, great derangements and contortions of strata	Grits, slates, slaty grits, limestones, etc.	Between the mouth of the Ancram creek and Redhook.

No.	Strike.	Dip.	Kind of rock.	LOCALITIES.
		RENSSELAER COUNTY.		
1	N 10° to 20° E.	Eastward at high angles from 40° to 90°; slates often contorted	All the rocks of the county	Over the county generally; some few local exceptions; a few examples only subjoined.
2	North a few degrees east	Both east and west, anticlinal from 38° to 58°	Grits and slates of the Hudson river group	About one and a half mile east of Greenbush, on the road to Sandlake.
3	do do	Eastward 50° to 80° ..	Slates of the Hudson-river group	About two and a half or three miles east of Greenbush.
4	NNE	Vertical	Limestones and slates of the Hudson-river group	About four or five miles east of Greenbush.
5	do	ESE 50° to 80°	Red and green slates, and coarse green grits	Between Sandlake and the Tuckawassick kill.
6	do	do do	Greenish talcose and chloritic slate	Near the northeast corner of Nassau.
7	do	do 70°	Red and green slate	Near the west part of Stephentown.
8	do	do 10° to 60°	Slate and limestone, like those of Lebanon springs	Near the east part of Stephentown.
9	do.....	do 50° to 90°	Slate and slaty limestones of the Hudson-river group	On the macadamized road from Troy to Bennington, two to four miles from Troy.
10	do	do 50°	Red slate.....	On the macadamized road from Troy to Petersburgh, about six miles from Troy.
11	do	do	Coarse greenish grits	On the same road, about eight miles.
12	do	do 50° to 90°	Red slate.....	On the same road, about ten miles.
13	do	do	Coarse greenish grit	On the same road, about eleven miles.
14	do	do	Red slate.....	On the same road, about twelve miles, between the small lakes in the north part of the town of Grafton.
15	do	do	Coarse greenish grit	On the same road, about thirteen miles, and so on to the top of Petersburgh mountain.
16	do	do	Chloritic slate.....	On the east descent of Petersburgh mountain.
17	do	do 30° to 50°	Sparry and blue limestone .	Along the valley at the base of Petersburgh mountain.
18	do	do 50° to 80°	Metamorphic limestone ...	At the corner of Massachusetts, Vermont and New-York.
19	do	do do	Slate, chloritic and talcose.	Farther towards Hoosick from Williamstown, in Vermont.
20	do variable.	do do	Limestone, contorted and metamorphic	Still farther towards Hoosick from Williamstown.
21	do	do do	Talcose and chloritic slates and quartz	Near where the above road enters the northeast corner of Petersburgh, in Vermont.
22	do	do do	Talcose slate	North part of Petersburgh.
23	NW	NE	Limestone, sparry and blue	About two miles from Hoosick four corners on the road to Williamstown.
24	NNE	ESE 30°	Limestone and slate	About one mile from the above, towards Hoosick.
25	do	do 30° to 40°	Roof slate	Warren's and various quarries between Hoosick four corners and the Wallamsack river.
26	NW and SE ..	SW	Blue limestone.....	On the road from Hoosick falls to Cambridge, near the junction of the Hoosick and Wallamsack.
27	NNE	Vertical and variable .	Slates and grits	Wickmin's quarry, in the town of Lansingbusgh. Pl. 3, fig. 3.
28	do	ESE 30° to 40°	Grits	Quarries near Troy, on the hill.
		WASHINGTON COUNTY.		
1	NNE	ESE 10°	Gneiss, Potsdam sandstone, etc.	Whitehall.
2	do	do	do do	Three or four miles from Whitehall, on the road to Fort-Ann.
3	NNE	ESE 10°	Gneiss, Potsdam sandstone, etc.	Eight or nine miles from Whitehall, on the road to Fort-Ann.

No.	Strike.	Dip.	Kind of rock.	LOCALITIES.
4	.....	Horizontal	Slate and limestone.....	Between Fort-Ann and Sandyhill. The rocks generally of Washington county, dip eastwardly at a high angle, as represented in Pl. 28, figs. 1, 2, 3. There are however, many local exceptions, a few of which will be noticed.
5	WNW	NNE, high angle	Limestone	In Easton, two or three miles south of Union village. Transverse elevation and stratification.
6	NNE	ESE, high angle	do	In Easton, two or three miles south of Union village, near the preceding locality, dip and strike in the usual directions.
7	do	Vertical	Slate like roof slate	At the "Big falls," below Galesville, on the Batten kill.
8	do	ESE 20° to 60°	Limestone	On the west side of Bald mountain, usual strike and dip.
9	WNW.....	NNE, high angles often contorted	Limestone and slates.....	On the south end of Bald mountain, transverse strike and dip.
10	North	East 60°	Slates of the Taconic system	Two miles north-northeast of Sodom.
11	N 10° E	Eastward 80° to 90° ..	do do	Two miles northeast of Sodom.
12	.....	Nearly horizontal	Slates and limestones of the Champlain division	Near Baker's falls.
13	NNE	Vertical and ESE 30° nearly	do do	Near Baker's falls, east of the axis of disturbance.
14	....	Horizontal	Slates	Along the canal near Kingsburyville.
15	NNE	ESE 40° to 60°	Limestone	East of the canal in Kingsbury, at the quarries.
16	do	do 10°.....	do	Northwest part of Hartford.
17	do	do 70°	Calcareous slate.....	Central and northern parts of Hartford.
18	do	Very high angle and contorted, dips every way	Slate of the Champlain division (Hudson slates)	Fort Edward and Fort Miller, along the Hudson and within two or three miles.
19	North	East 40°	Quartz rock and Potsdam sandstone	Fort-Ann, one mile north of Griswold's.
20	NE	SE 40°	do do	Fort-Ann, one and a half mile northeast of Griswold's.
21	E and W	S 10° to 40°	Potsdam and calciferous sandstone, and blue limestone	Fort-Ann northwest and west of Fort-Ann village, in various places up the valley of the creek, dipping off southwardly and southeast from the primary ridges, and sometimes apparently pitching under them.
22	NNW.....	ENE 70 to 90°	Taconic slates	In Hampton on the road between Poultney and Whitehall.
23	do	do 30° to 60°	Potsdam sandstone, calciferous sandstone, and limestone	Between Whitehall and Hampton, in Whitehall.
24	North	East 40°	Gneiss	Northeast part of Dresden and southeast part of Putnam. The limestone opposite on the Vermont shore is horizontal.
25	WNW	ENE, high angle	do	One and two miles north of last locality, in Putnam. Transverse axis.
26	do	do do	do	Two miles north of preceding locality, in Putnam. Transverse axis.
27	.....	Horizontal	Limestone.....	Along Lake Champlain in various places, indicated on the State map.

ROCKLAND COUNTY.

1	Very variable, but generally NE and E	Very variable, but generally north and northwest from 5° to 20°	Red sandstone	On the banks of the Minisheconga creek, in Haverstraw.
2	N 20° E	N 70°, W 10°	Coarse red sandstone	Depew's quarry, one-half mile north of Van Houtens, on one of the ridges between the Hackensack and Barber's creeks.

No.	Strike.	Dip.	Kind of rock.	LOCALITIES.
3	NE and SW ..	Nearly horizontal	Red calcaraous conglomerate	Near Beebee's furnace, on the banks of the Minisheconga creek.
4	do do ..	Vertical.....	Talcose slate, on the northwest side of the above, conglomerate	do do do do
5	NE and NNE .	NW and WNW 1° to 8°	Red sandstone	Generally underlying the trap rocks of Rockland county.
6	NNE and NW	WNW and SW, at a small angle of 1° to 5° and 8°	do	From Dobb's ferry to Haverstraw at Nyack, and various places.
7	N 12° E, but variable	Eastward 12° to 80° ..	Junction of the limestone and talcose slate	At Tompkins' quarries on the Hudson, one and a half mile above Stony point. Rocks warped and variable.
8	N 20° E	N 70° W 10°.....	Red sandstone in both parallel ridges	Between Hackensack and Barber's creeks.
9	NE	SE	Verd antique marble.....	On the shore of the Hudson, about one mile south of Caldwell's landing (Cassels).
10	NNE	Vertical	Gneiss streaked with hornblende.	Near the turnpike gate on the top of the mountain.
11	do	Eastward 70° to 85° and vertical	Gneiss, with beds of granite	Farther west than the above, on the turnpike.
12	E and W nearly	.....	do do	On the western declivity of the eastern range of mountains, towards Kyle's valley.
13	N 30° E	.....	do do	A few rods from the preceding, which was only a local variation from the general range of N 30° E.
14	Northward	Westward nearly horizontal	Red sandstone	Blauvelt's quarry three miles northwest of the "New city," on a hill one hundred feet high.
15	do	do do	do	Westervelt's quarry, on the shore one mile above Nyack.
16	do	do do	do	Various quarries along the shore of the Hudson between Piermont, Nyack, and Haverstraw.

ORANGE COUNTY.

1	NNE to NNW	E 30° to 45°	Slate and limestone	Between Newburgh and Marlborough.
2	NNE	WNW 10° to 20°....	Barnegat limestone	At the northeast corner of the county.
3	do	ESE 20° to 80°	Slates and grits	Nearly all the country east of the Walkill river, rocks dip eastward.
4	do	WSW, high angle, generally often vertical	do	Along the Walkill and westward from the New-Jersey line to Rondout, rocks dip westward.
5	N 45° to 50° E.	SE 45° to vertical	Gneiss of the Highlands ..	Highlands of Orange (Dr. Horton).
6	NE	NW	Gneiss and various rocks ..	On the west side of Butter hill, and on the road from West-Point to Canterbury.
7	NNE to NE...	ESE to SE from 30° to 50°	Argillite, Hudson slate....	Between the Highlands and Shawangunk.
8	NNE	ESE	Grits, greywacke, dip apparently under the primary rocks, conformable and at the same high angle	To the northeast of Bellevale mountain, on the western side of the ridges. One mile west of the "Friends" church in Monroe. On the west side of Goose-pond mountain, and on the west side of Sugarloaf mate.
9	NE	SE 30° to 60°	Newburgh limestone.....	Generally in the vicinity of Newburgh.
10	N and NE	W and NW	Newburgh limestone, or Barnegat, or calciferous	Hampton on the shore of the Hudson, and Dow's corner, another high ridge at the north end of Newburgh bay.
11	NE	SE	do do	One half mile southwest of Ketcham's mill.
12	NE	SE 3° to 10°	Fossiliferous limestone of the Champlain division	Near Thomson's limekiln, Goshen.
13	North	Horizontal, slightly westward	Black, grey, compact limestone, not fossiliferous	Mount Lookout, one mile west of above.
14	NE	NW very slight.....	do do	Great island in the drowned lands, and thence southward to the New-Jersey line.

No.	Strike.	Dip.	Kind of rock.	LOCALITIES.
15	NE	SE, high angle	Conglomerates, slates, etc. like those of Bellevale mountain, Skunnemunk, etc.	On the southeast side of Round hill; rests upon the primary.
16	NNE	ESE 60° to 70°	Gneiss	Captain Faurot's quarry, between Fort-Montgomery and West-Point.
17	WNW and N 20° W	NNE 40° to 50°	Gneiss with beds of granite	Below Fort-Montgomery, at and near Mrs. Pell's. The strata of gneiss with beds of granite, on Waggon's islands in the Horserace, between Fort Montgomery and the eastern point of the Dunderberg, are transverse in many places, viz. the strike from west-northwest to east-southeast, and dip variable. This seems to be on one of the transverse axis of elevation, viz. the one from Peekskill, and farther east by Anthony's-nose and the Dunderberg, Fort Montgomery, and so on farther west-northwest, along which in many places the strata have a strike to the northwest, west-northwest and west, with a dip variable north or south, and the rocks often in great confusion over a breadth of one-half to a mile from northeast to southwest.
18	Northward	Eastward	Gneiss, underlies the magnetic iron ore	Forshee mine, Monroe.
19	N 50° E	.....	Limonite, bed like that of Townsend's mine	About two miles north of Woodbury furnace, northwest of the Highland mills, one-half mile east of the mills, and also south of them on the road side.
20	do	SE, high angle nearly vertical	Red and other slates, grits and limestone	Townsend's mine in Canterbury, and near the Highland mills.
21	NNE and NE .	ESE and SE	Gneiss and hornblendic gneiss, with veins and beds of granite	From Greenwood furnace to the Ramapo works.
22	NNW	Variable, generally northward	Gneiss and various rocks ..	Many places about Fort Montgomery on the axis of disturbance, ranging west-northwest, and east-southeast by Fort Montgomery.
23	NNE	Eastward 60° to 90° ..	Gneiss, limestone, and augitic rocks, with granite	Between Fort Montgomery and West-Point. The dip at high angles may be seen all along the rocky shore, and especially near Buttermilk falls, both north and south in high cliffs, and opposite Blockhouse point and the hospital near West-Point.
24	NW	.....	Impure limestone, contains pyrites, augite, serpentine, etc.	Near Mr. Potter's, one mile northwest of Fort Montgomery.
25	About WNW?	About NNW.....	Gneiss, and hornblendic gneiss	Near the Cascade, about one-half mile from Washington valley, and one and a half from West-Point. This is on a transverse axis passing through Constitution island.
26	NNE	WNW about 70°	Magnetic oxide of iron, in gneiss and hornblendic gneiss	Kronkite's iron mine, about five miles southwest of West-Point, Cornwall.
27	do	ESE 40° to 60°	do do	Forest of Dean iron mine, in the town of Cornwall. Vide Pl. 5, fig. 9.
28	N 20° E	Vertical	Gneiss, granite, and limestone	At the locality of white limestone, near Duck-cedar pond. Vide Pl. 5, fig. 11.
29	N to W.....	E to E 6° to 12°.....	Gneiss, with granite and magnetic oxide of iron	At Stirling iron mines, Monroe. Vide Pl. 30, figs. 4 and 5.
30	NNE	ESE	Gneiss, traversed by a trap dyke several yards wide *	On the summit of the mountain, between Grassy point and Queensbury forge, west of the pass of the Tymp.

* Trap dykes are quite common in the mountain region of Orange and Rockland counties. Many were observed, but the localities of few were noted.

No.	Strike.	Dip.	Kind of rock.	LOCALITIES.
			ULSTER COUNTY.	
1	NNE.....	WNW 70°	Grits and slates (Erie), and limestone (Helderberg)	Near Redbridge, between Sullivan and Ulster counties.
2	do	WNW 20° to 60°	Shawangunk grit and limestone	Ulster lead mine.
3	.....	WNW	do do	Rosendale on the right and left banks of the river. Vide Pl. 7, fig. 3.
4	NNE.....	Arched and broken ...	Slates and grits	Dashville, falls of the Wallkill. Vide Pl. 7, figs. 7, 8 and 9.
5	do	ESE 30° to 80°	do	The usual strike and dip about Dashville, and that region towards Esopus and Marlborough.
6	Northward	Westward 5° to 10° ..	Helderberg limestone	Two miles west of Saugerties.
7	do	Eastward 60° to 80° ..	Slate and grits	Near Saugerties, often much contorted and deranged.
8	NNE.....	Vertical and variously inclined	Slate and limestone, unconformable	On the road from Saugerties to Kingston. Vide Pl. 7, fig. 9.
9	Northward	Westward 3° to 6° ...	Limestone of the Helderberg division	One-half mile southeast of Kingston, on the road to Wilbur.
10	.....	Variable	Black, argillaceous, scaly, slaty limestone, both laminated and stratified	Three-quarters of a mile southeast of Kingston.
11	NNE	do	Limestones of the Helderberg division	Various examples about Kingston. Vide Pl. 7, figs. 1, 2, 3, 4, 5, 6, and 9; Pl. 8, figs. 4, 5, 6, 7, 8, 9, and 10.
12	do	ESE 40°	Limestone of the Helderberg division, containing fossils	One and three-quarters of a mile from Bridgeport towards White's quarries, beyond Flint's quarries.
13	NE	NW 3° to 5°	Grits and slates of the Erie division	West of Esopus creek to Woodstock, all the rocks of Mamakating valley, and west for some distance, dip westward.
14	N 20° E	N 70°, W 30°	Limestones of the Helderberg division	At the lead factory at the falls of the Esopus, and for a mile below. Vide Pl. 8, fig. 6.
15	.....	Very variable.....	Limestones, slates, etc., unconformable	On the Rondout, near Wilbur. Vide Pl. 26, fig. 1.
16	NE	SE 60°	Slates and grits	Near Wilbur on the right bank of the Rondout.
17	NNE, ...	ESE, high angle	do do	At Eddyville, but often contorted. Vide example, Pl. 9, fig. 11.
18	do	ESE 40° to 60°	Limestones of the Helderberg division	At Pine mountain, near Rondout, often very irregular.
19	do	WNW 80°.....	do do	Hasbrouck's quarries, on Pine mountain.
20	.....	Nearly horizontal	do do	On Pine mountain, where the road from Kingston to Kingston-point landing crosses.
21	NNE	WNW 80°	Limestone of the Helderberg	"High rocks" on the Hudson, one mile northwest of Kingston-point landing. Vide Pl. 8, fig. 7.
22	.....	NW 3° to 14°	Limestone of the Helderberg division	Between Kingston and Hurley, on west side of anticlinal axis. Vide Pl. 8, fig. 8; Pl. 27, fig. 8.
23	NNE	ESE	do do	Between Kingston and High falls, on east side of anticlinal axis. Vide Pl. 8, fig. 9.
24	NNE	ESE 30°	do do	On the east side of the "Two ponds."
25	About N 20° E, and S 20° W	ESE and WNW	do do	Anticlinal axis through "Two ponds," and extending far. Plate 26, figs. 2 and 3.
26	S 20° W and N 20° E	WNW, variable from 2° to 40°	Limestone of the Helderberg division, and Shawangunk grit	At Lawrenceville and the vicinity. Anticlinal axis near Lawrenceville. Vide Pl. 26, figs. 4 and 5.
27	NNE	WNW, variable, waving and faults	Grit and limestone.....	Between the Rondout at the High falls, and the Shawangunk mountain. Vide Pl. 26, fig. 7.
28	do	WNW 4° to 20°, undulating	do do	Between Rochester and the Shawangunk mountain. Vide Pl. 26, fig. 7.
29	N 70° E	N 20°, W 10°	do do	On the Shawangunk south of Rochester.
30	NNE	WNW high angle 40° to 60°	Shawangunk grit	On the road over the mountain east of Ellenville.
31	do	WNW 12° to 30°	Graptolitic slates, etc.	On the road over the mountain east of Ellenville, after passing over the edges of the Shawangunk grit.
32	do	WNW 40° to 90° ...	do do	Higher up the mountain.
33	.....	Nearly horizontal ...	Shawangunk grit	Sam's point, a high point on the Shawangunk mountain.

No.	Strike.	Dip.	Kind of rock.	LOCALITIES.
34	NNE	WNW 30° to 50°	Black limestone of the Helderberg division	In the Mamakating valley on the east side of the Sandberg creek, two miles north-northeast of Redbridge.
35	Northward	Eastward 10 to 15° ...	Black slate of the Champiain division	At the reputed "coal mine" near the Coxenclove creek, at the west base of the Shawangunk mountain.
36	NNE	WNW 4° to 5°	Shawangunk grit	One-half mile north-northeast of the "coal mine."
37	NNE nearly...	Eastward, small angles	Shawangunk grit, covered in some places by red slate and by Helderberg limestone	Near the Coxenclove creek, on the road from Springtown to High falls.
38	NNE	WNW 1° to 3°.....	Slates and grits of the Erie division	In the valley of the Esopus, northwest of the Mamakating valley.

GREENE COUNTY.

1	Northward	Westward 5° to 10° ..	Limestone of the Helderberg division	A mile west of New-Baltimore, two miles west of Saugerties.
2	do	do do .	Slate	Two miles west of Coxsackie. Pl. 8, fig. 3.
3	do	do 10°.....	Limestone.....	do do do
4	.....	Highly inclined	Grits and slates	At and near Catskill village.
5	NNE.....	ESE 60° to 70°	Slates and grits	One and a half mile southwest of Catskill.
6	N 22° E to W 32° E	Vertical and some dip eastward and some westward	do do	At the base of the limestone ridge, about one and a half or one and three-quarters of a mile southwest of Catskill.
7	do do	Westward 8° to 60° ..	Limestones of the Helderberg division	About one mile south of the last locality, and extends with the same general strike and dip, south-southwest to the Esopus falls.
8	.....	Nearly horizontal and slightly to westward	Slates and grits of the Catskill division	About Durham, Prink-street, Preston's hollow, Oakhill, etc.
9	Northward	Westward 25° to 60°, warped surface	Helderberg limestone	Between Catskill and Madison, on the east side of the creek.
10	do	Westward 10° to 20° .	Fossiliferous rocks of the Erie division	North and northwest of Madison, one-half to a mile.
11	do	Westward 3° to 20° ..	Rocks of the Erie and Catskill divisions	Between Catskill creek and the base of the Catskill mountains.
12	do	do ½° to 1°	Rocks of the Catskill division	Catskill mountains.
13	do	do 10° to 15° ..	Helderberg limestone	Three miles west of Athens.
14	do	Very irregular and contorted	Slates and grits of the Champlain division, and limestones of the Helderberg	Between Catskill and Madison, and between Catskill and the stone bridge of the Kaaters' kill towards the Pine-orchard, and along the railroad, and towards Athens and Coxsackie.
15	NNE	ESE 70°	Slate and slaty grits of the Champlain division	Above Four-mile point, where coal was dug.
16	NW	NE	do do	Some local variations in the vicinity of the preceding.
17	.....	NNW, ...	do do	One and a quarter mile below Athens, right bank of the Hudson.
18	WNW	ESE 5° to 10°	Slate and slaty grits	One and a half or two miles northwest of Coxsackie.
19	.....	Horizontal	Helderberg limestone	About two miles northwest and west of Coxsackie.
20	WNW	ESE, high angle	do do	Two or three miles northwest and west of Coxsackie.
21	ENE	WNW 10°	do do	Near the school-house four miles from Coxsackie.

ALBANY COUNTY.

1	NNE	ESE 60° to 80°	Slate of the Champlain division	Between Albany and Coeymans.
2	ENE	WNW 6° to 70°	Slate and grits of the Champlain division	Island just below Coeymans.
3	.....	Eastwardly 60° to 70°	do do	One mile below Coeymans, strata very much deranged.
4	.....	Eastwardly high angle	Slate, graptolitic slate, grits, slaty grits, etc.	On the banks of the Norman's kill one and a half and two miles from Albany, on the road to Schoharie, and thence to the mouth.
5	.....	SW at a slight angle ½° to 2°	Oriskany sandstone, and other rocks of the Helderberg division.	Also, Vide Pl. 27, fig. 7.

No.	Strike.	Dip.	Kind of rock.	LOCALITIES.
6	NW	.....	.....	Along the road east of Knoxville village.
7	NNW	WSW at a very small angle, ½° to 2°	Limestones of the Helderberg division	On the road from Albany to Clarksville, eight to twelve miles from Albany.
8	do	do do	do do	Near Salem, one-half mile west in New-Scotland.
9	do	do do	Limestones, grits, and slates of the Erie division	Coeymans and Westerlo, well exposed at the flagstone quarries, and in the valley of the Hawnakran's kill, and on the terraces on the flanks of the mountains.
10	NW	SW very slightly	Helderberg limestones and Marcellus shale	On the Helderberg mountain, between Van Schaick's and the Corporation village.
		SARATOGA COUNTY.		
1	Westward, ...	Southward, ...	Quartz rock or Potsdam sandstone, calciferous sandstone and limestone	Along the southern side of the primary rocks, from Saratoga to the west line of the county.
2	NNE variable .	ESE, variable 3° to 10°	Limestone	Saratoga-Springs.
3	Variable	Nearly horizontal	Graptolitic slate	Ballston-Spa.
4	do	do do	Slate and slaty grits, Hudson slates	North of Schenectady for a few miles, and along the railroad.
5	do	Broken up and very much contorted	do do	Along the Mohawk, below Alexander's bridge and the aqueduct, to the Hudson.
6	Variable, generally NNE and N	The same, but generally eastward at high angles	do do	Along the Hudson to Baker's falls.
7	do do	do do	do do	Northward from the Mohawk by Saratoga lake, east side, to Baker's falls.
8	NNE	ESE 30° to 90°,.....	Gneiss, hornblendic gneiss, with beds of granite and limestone, and magnetic oxide of iron	From Saratoga-Springs throughout the mountain region of the northwest part of the county.
		SULLIVAN COUNTY.		
1	NNE	WNW 30° to 40°....	Grits and slates, with some anthracite.	Two miles west of Red-bridge at the "coal mine."
2	E and W	North 0° to 3°	Grits and slates of the Catskill, etc. rocks	Near the mouth of the Lackawaxen creek.
3	NE	NW 0° to 3°	do do	Between Port Jervis and the Lackawaxen creek.
4	NNW	ENE 0° to 3°.....	do do	do do do do
5	Northward	Westward 5° to 30° ..	Slates and grits of the Catskill and Erie divisions	About one to two miles on the road from Wurtsboro' to Monticello.
6	do	do ½ to 3°....	do do	On the Lumberland turnpike.
7	Variable, SW to to NW and NNE	NW, WSW, variable angles from horizontal to 3°	Slates, grits, etc., of the Erie and Catskill divisions	Along the Delaware river.
8	.....	Nearly horizontal	do do	General position of the rocks in the interior of the county.
		DELAWARE COUNTY.		
1	.....	Nearly horizontal, slight undulations, the troughs of which seem to be in the valleys of the main streams	Rocks of the Catskill and Erie divisions	Over the whole county, the dip is so slight as to be imperceptible to the eye where examined.
		SCHENECTADY COUNTY.		
	WNW and NW	Nearly horizontal, dipping generally to the S, SSW and SW from ½° to 3°	Champlain division	Over most of the county. except between Schenectady and Niskayuna.
	Variable	Very much broken and contorted in some places	do do	Near Niskayuna, and some deranged near Alexander's bridge and the aqueduct.

No.	Strike.	Dip.	Kind of rock.	LOCALITIES.
			SCHOHARIE COUNTY.	
1	Westward	Nearly horizontal	Slates, slaty grits, and grits of the Erie and Catskill divisions	Strikersville falls and Gilboa.
2	NW	SW very slightly	Helderberg limestone, fossiliferous	One or two miles south of Middleburgh bridge.
3	do	SW at a very small angle of ½° to 3° ...	Helderberg limestone, and the rocks generally of Schoharie county in every part, viz. those of the Champlain, Ontario, Helderberg, Erie and Catskill divisions	Every part of the county as a general rule, strike northwest to west, and dip southwest to south, nearly horizontal, but perceptible to the eye.
4	do	SW 1 foot in 15 to 1 in 50, undulating	Slaty grits of the Champlain division	Between Esperance and Burton's bridge, five miles north of Esperance.
5	West	South about 1° to 1½°, nearly level to the eye	Helderberg and Ontario divisions	Sharon springs. Vide Pl. 25, fig. 3.
6	do	S very slightly, ½° to 2°	Erie, Helderberg and Ontario divisions	From Sharon springs to Summit four-corners.
7	do	do do	Rocks of the Champlain, Ontario, Helderberg and Erie divisions	From Spraker's basin and Noses on the Mohawk, to Summit four-corners. Vide Pl. 12, fig. 1.
8	do	South	Rocks of the same divisions and the Catskill division	From Esperance to Prattsville, across Schoharie county. Vide Pl. 25, fig. 6.

It will be observed, by consulting the preceding tables of strike and dip of the rocks, and the directions of joints, that there are two main directions in which the strata have been broken and deranged, viz: north-northeast and south-southwest for one system of elevation and fracture, and west-northwest and south-southeast for the other, though intermediate directions are not uncommon. These systems correspond in great circles, on an artificial globe, to others in other parts of the world; but without farther and more detailed examinations, it would be premature to infer their identity in time. Another system of fractures and derangements runs a few degrees west of north, and another about northwest.

The main transverse west-northwest upheaves are,

1st. One across the Hudson at Sparta and Verdrietje hook.

2d. One across the Hudson near Stony point, which is believed, from slight examinations made, to extend by Mount Eve to Carpenter's point on the Delaware, and eastward by Mr. Cruger's in Cortland, and across the Croton river into Connecticut.

3d. One across the Hudson from Peekskill, and several miles eastward through the Horse-race, along the base of Anthony's Nose mountain, Waggon's islands, Fort Montgomery, near Queensbury forge, across the Clove near Monroe, the outlet of the Drowned-lands, Mount-Hope gap in the Shawangunk, Cuddebackville and the falls of the Mongaup.

4th. Another across the Hudson at Constitution island, opposite West-Point, and the cascade half a mile west-northwest of the Cadet's monument on the west, and by the soap-stone, serpentine, etc. beds in the east part of Phillipstown to the eastward.

5th. Another three to four miles north of Newburgh, and on to the high points of the

Shawangunk mountains, where they are fractured in north-northeast and west-northwest directions, as at High point, Sam's point, Buntico point, Great Mogunk, etc., and eastward by the arsenic mine and beds of black serpentine and diallage in Carmel, Putnam county. Several more between Newburgh and Baker's falls, as in Marlborough, above Poughkeepsie, Rhinebeck, Redhook, Germantown, Coxsackie, Easton, Greenwich, etc. might be named.

6th. Another across Lake Champlain, in the the southeast part of Putnam, Washington county.

7th. Another by Putnam, towards Anthony's Nose, on Lake George.

These have none of them been traced continuously very far, and are not considered as well ascertained lines of disturbance to any great distance. This subject is one that is only begun to be investigated. Some facts are registered, and subsequent minute examinations will be required to develop the truths that are yet in obscurity.

Another set of fractures and lines of contortion of strata having a northwest and southeast direction, is believed to have been observed, and which cross the Hudson in the greatest numbers between Newburgh and Troy. Their general course is about parallel with the course of the northwest part of the Esopus kill and the Catskill creek, and seem to follow very frequently the valleys of the streams.

It is believed to be of much importance to trace out the lines of disturbance and upheaving action, not only in a scientific point of view, but in relation to the metalliferous and other valuable mineral deposits. It is considered *certain* that *some* of these deposits are at the intersections of such lines of disturbance and upheaving action, from the facts already observed; enough to render it *probable* that the tracing out of such lines will lead to valuable discoveries.

Some of the effects of elevatory movements along the main systems of fracture have already been alluded to: vide pp. 317, 320, 330, 334, 356, 357 (365, note), 367 to 368, 374, 375, 377, 381, 388 to 390, 405 note.

The main systems of north-northeast and south-southwest elevation may be considered to be,

1st. That extending through the island of New-York, Staten island, and the west end of Long island at and near Hurlgate, northwards through the western and central portions of Westchester and central part of Putnam counties, and forming Chesnut ridge and Winchell's mountain in Dutchess county.

2d. The Highlands, which is composed of a great number of short parallel axes situated in echelon with regard to each other, and giving the general direction of the aggregate elevations of the highlands a northeast and southwest course. Many of these short parallel axes are prolonged so as to produce other elevations still further north-northeast; though by the subsiding of the ridges to the north, they disappear, and in consequence of elevations at the transverse as well as at the longitudinal fractures, other elevations spring up along the same line. One or two of these prolonged, constitute the Marlborough mountains; another the Comfort hills, the fractures and high points of the Shawangunk mountain west of Springtown,

the broken ground about Kingston, and forms the *Hudson river axis* for more than one hundred miles to Baker's falls. Others form the ranges of hills east of the Hudson.

3d. Another forms the Shawangunk axis from the great bend of the Delaware at Carpenter's point to Ellenville, where it leaves the Shawangunk mountain and shows itself only by broken masses and faults in the Mamakating valley, and by faults, fractures and gorges in the Catskill mountains, still further to the north.

Many others might be described, but it is believed that they may all be referred to those that have caused the highland ridges, and are prolonged to the north a great distance. The ridges in the mountainous parts of Saratoga and Washington counties have the same general dip and strike as those of the Highlands, and are composed of the same rocks, and are supposed to have been elevated by the same cause at the same period, and their axis may be considered the same as those of the Highlands; but they have shown less marked effects under the enormous masses of the Catskills, than where the rocks of the Erie and Catskill divisions were not developed. Professors H. D. and W. B. Rogers, of Pennsylvania and Virginia, have been, and are still engaged in investigating the phenomena of these and other axes of the same epoch in New-Jersey, Pennsylvania and Virginia, and it is expected that much light on this interesting subject will be derived from the results of their labors.

2. Joints and Veins.

No.	First set.	Second set.	Third set.	Kind of rock.	County.	LOCALITY.
1	N 20° E	.....	.....	Greenstone, coarse grained	Richmond...	At the quarries called the granite quarries, three miles southwest of Tompkinsville.
2	About N and S	Nearly E and W	.....	Roof slate	Columbia ...	Foster's quarries, Hillsdale.
3	.....	E and W ...	.....	Limestone	Edge of Connecticut, nr. Dutchess	Vein of lead ore on Mr. Lake's farm on east side of Indian pond.
4	.....	.....	N 70° E ?...	Slate near the sparry limestone	Columbia ...	Lead mine, Ancram.
6	.....	E and W ...	.....	Sparry limestone	Dutchess....	Bockee's and Bryan's lead mines, strata nearly vertical. Plate 23, fig. 2.
7	.....	.....	N 60° E	Calciferous sandstone containing quartz crystals	do	Three miles east of Rhinebeck, in calciferous sandstone quartz veins.
8	.....	NW	.....	Gneiss granite, and all primary rocks	Westchester.	Between Byram river and New-York.
9	Nearly N & S	Near E & W	.....	.....	Columbia ...	Mount Bob and Becraft's mountain.
10	.....	N 20° E	N 70 E	Grits	Ulster	On the banks of the Wallkill, one mile above Dashville.
11	.....	N 60° W and S 60° E	.....	Shawangunk grit	do	Ellenville lead mine, one mile northeast from Ellenville.
12	N 20° E	N 60° W ...	.....	Limestone and Shawangunk grit rocks	do	At the base of the Shawangunk, south of Rochester.
13	.....	do ...	.....	do do	do	Red-bridge and two miles northeast.
14	.....	NW	.....	Gneiss (pyritous) veins of quartz	Putnam.....	On Jedediah Wood's farm, at the locality of the reputed lead mine.
15	NNE and SSW dipping westward.	WNW and ESE nearly vertical.	.....	Gneiss and hornblendic gneiss	do	All along the rocky shore from West-Point to one mile below Buttermilk falls. Granite veins often traverse these rocks, and granite is interlaminated and in irregular masses in these rocks.
16	N and S, N 20 to 30°E	N 55 to 60° W	N 50 to 60° E	Grits, slates, and slaty grits of the Erie division, joints very smooth and nearly vertical	Schoharie ...	North Blenheim P. O.
17	do	do	do	Champlain division, very smooth and nearly vertical	do ...	Near Esperance in quarries.
18	do	do	do	do do	do ...	Near central bridge, one-half or three-quarters of a mile north on the road to Grosvenorville.
Many places.	do	do	.....	Slates and grits of the Erie and Catskill divisions	Sullivan and Delaware	Beautifully developed along the Delaware canal, from Port Jervis to the mouth of the Lackawaxen creek, and on the Delaware generally.

The preceding table, giving the directions of joints and veins, contains but few recorded facts, because while making observations over the country under examination, when the directions conformed to the *general* directions of the joints, they were very rarely noted. Where the rocks are horizontal, the joints are usually vertical; where they are highly inclined, one of the sets of joints (usually the west-northwest set) is vertical or nearly so, while the other is more or less inclined. This inclination is usually to the westward where the dip is to the eastward.

The joints, or some of them at least, seem to have been formed previous to the elevation of the strata to their inclined position, and to have exercised an influence in the form and position of elevated masses of hills and mountains, as noticed in pages 333 and 334 of this volume.

The causes of these joints are unknown. Various theories have been proposed to account for them, and none of them afford decisive or even very strong evidence of their origin. The cause or causes of joints is considered an interesting and important problem, and the determination of the direction and dip of the different sets of joints over extensive areas in various distant regions of the globe may lead to interesting results. Query: Do the same sets of joints, prolonged to distant points on the surface of the globe, correspond to great circles? 2d. If they do so correspond, do they correspond also to any great lines or belts of upheaving action? Or, 3d. Do they correspond to *great circles passing through the same axis as that along which great upheaving action or derangement, and folding and wrinkling of the strata, have been effected?* These queries are addressed to geological observers, as probable, from facts already observed; and that such effects as we see connected with joints, may probably have been produced by subsidence of parts of the earth's surface and elevation of others.

3. Ages of rocks, and periods of elevation and metamorphic agency.

(A). Of the ages of the rocky strata, from the Potsdam sandstone, the lowest sedimentary and fossiliferous rock of which we have any knowledge, to the conglomerate of the base of the Coal formation, there is no doubt. The rocks are well developed, and fairly exposed to observation in numerous places where they have been examined, and are found in superposition as they have been described in this volume, and in the final geological reports by Professors Emmons and Vanuxem.

The taconic rocks have been discussed as imperfect metamorphic rocks. Vide pp. 422, 438.

The upturned slate and grit limestone, etc. rocks of the Hudson valley, have been identified with the horizontal ones of the Mohawk valley (Vide pp. 377, 378) on the one hand, and their passage into the Taconic rocks of the other rendered highly probable (pp. 422, 438).

The upturned rocks of Bellevale, Skunnemunk, Goose-pond, etc. mountains, and of Townsend's iron mine and Pine hill, have been referred to the rocks of the Ontario division. (Vide pp. 362 to 366.)

The RED SANDSTONE OF ROCKLAND COUNTY AND NEW-JERSEY, has been shown by trains of evidence to be almost certainly the "new red sandstone." (Vide pp. 293, 294.)

The TRAP ROCK OF THE PALISADES has been shown to be older than the quaternary and drift deposits, and newer than the red sandstone of Rockland and New-Jersey, and was probably erupted at the epoch of the marl and green marl deposits of New-Jersey. (Vide pp. 179, 202, 282, 284, 285.)

The LONG-ISLAND DIVISION is shown to be probably equivalent to the New-Jersey marls and potter's clay formations of Prof. Rogers' final geological report of New-Jersey, covered perhaps by tertiary in some places. (Vide pp. 246, 272, 273.)

The DRIFT DEPOSITS, *and the main effects of the drift epoch*, have been shown to have *preceded* the epoch of the quaternary of the Hudson, Champlain and Mohawk valleys, and the superior deposits of Long island, and to have *succeeded* those included in the Long-island division. (Vide p. 168, and many places described on Long island and in the Hudson valley, where the drift is covered by the quaternary; and p. 248 et seq. where *they rest on the strata of the Long-island division, and perhaps on the tertiary.*)

The QUATERNARY DEPOSITS of the Hudson and Champlain valley, and of Long island, have been shown to have succeeded the drift, and may perhaps be considered as the effect of a continuation of the same causes that produced the drift, but modified in intensity, some boulders and pebbles being deposited in the clay beds of the quaternary.

The UPPER DRIFT is the last epoch of deposition preceding the alluvial causes. (Vide pp. 123, 135, 136, and 158.)

The METAMORPHIC ROCKS have been discussed in this volume, and referred to the period of the Champlain division. (Vide pp. 439, 463-4, 466 to 476, 486.)

The slate rocks are mica slate, argillo-micaceous slate, talcose slate, chlorite slate, talco-argillaceous slate, and argillaceous slate. The mica slate and argillo-micaceous slate predominate, but in some places pass gradually into the others by insensible changes in short distance, so as to render it obvious that they are contemporaneous. Where the *mica slate* comes in contact, or nearly in contact, with limestone, the latter is almost always crystalline, dolomitic, and frequently white; but when the *talc slate* is near the limestone, the latter is subgranular and generally grey; and generally the more argillaceous and less altered the slate rocks are, the less altered are the limestones, and they approach nearer to the compact and sparry limestones of the Champlain and Taconic rocks.

The *quartz rock* is not visible in *very* numerous localities in New York. Some have been described. Professors Hitchcock and Dewey have described it in various parts of Berkshire county, Mass., as connected with gneiss and mica slate.* It occurs also in New-Jersey (Formation No. 1, of Prof. Rodgers†), in Pennsylvania and Virginia.

The *limestones of Westchester and New-York* counties are like those of Putnam and Dutchess counties in New-York, Litchfield and Fairfield counties in Connecticut, Berkshire

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* Vide Final Geological Report of Massachusetts, 1842, p. 587, 583. American Journal of Science, vol. ix, p. 16.
† Final Geological Report of New-Jersey.

in Massachusetts, and Bennington in Vermont. They are associated with rocks similar in character, except that the argillaceous and talcy slates are no longer recognized, and the associated rocks are more gneissoid, hornblendic, granitic, and sometimes trappean, than those in New-York above the Highlands; but not, perhaps, more than those of the Hoosick and Green mountain range, of which this is an extension.

I should never have been led to consider these limestones and some of their associated rocks as *metamorphic*, but by tracing the gradual change of character so visible in eastern New-York above the Highlands, and in the western parts of Vermont and Massachusetts, and the same changes, only more rapid, in Rockland and Putnam counties, where the extensions of the taconic rocks are near the primary and the plutonic rocks; but having examined those transformations with some care, I have no hesitation in expressing the opinion that the *limestones of Westchester and New-York counties are metamorphic rocks*, and not so ancient as we have heretofore imagined.

We have been accustomed to consider the rocks of Westchester and New-York counties as among the oldest of the primary rocks. It is hard to yield that opinion; but I have perceived that evidence that I cannot resist, that the limestones at least, and probably the associated micaceous gneiss, mica slate, hornblende slate, and hornblende rocks, are metamorphic rocks, more recent in their change than the taconic rocks; in fact, that they are the rocks of the Champlain division, modified greatly by metamorphic agency and the intrusion of granitic and trappean aggregates.

(B). *Periods of elevation and disturbance of the strata.*

The facts accumulated on this subject, although numerous, are not such as to give all the certainty that is desirable; and it is presumed that the observations made by Professors H. D. and W. B. Rogers, in Pennsylvania and Virginia, and which will soon be published, may cause some of the results here deduced to be modified.

I have seen distinct evidences of but one period of elevation and disturbance preceding the age of the fossiliferous rocks, viz: 1. That of the primary of the Highlands of the Hudson, and of the primary mountains of Saratoga and Washington counties, on which the potsdam sandstone, calciferous sandstone and black limestone, etc. repose unconformably in many places, though conformably in others.

2. The earliest period of elevation and disturbance, after the commencement of the deposition of rocks that contain fossil remains, of which I have seen distinct evidence, is that which preceded the deposition of the Helderberg limestone, which lies unconformably on the upturned edges of preëxisting rocks, and which succeeded the deposition of the rocks of the Champlain division. It seems to have acted, in the First geological district, mainly through the Hudson valley, including the Highlands and Westchester county, and probably (if the veiws expressed of the age of the taconic and metamorphic rocks be true) through the Green and White mountain ranges, embracing most of Connecticut, Massachusetts, Vermont, New-Hampshire and Maine.

3. The next period of elevation and disturbance seems to have been subsequent to the deposition of the rocks of the Ontario division, and the effects of which are recognized from Green-pond mountain through Bellevale mountain, Goose-pond, Sugar-loaf and Skunnemunk mountains, Pine hill, by Townsend's iron mine, etc. where the rocks are vertical between the primary, and pitching under and resting on them; and along the Shawangunk mountains, where the same rocks are tilted to the west at high angles. This period *may* be the same as that next described, but is inferred to be different, from the fact that no rocks like those of the Erie and Catskill divisions are recognized among those above described. This evidence, however, is not deemed conclusive, as we have no evidence that any deposition of the materials of the Catskill division were ever deposited on that side of the ancient Hudson valley and Walkill.

4. The next period of elevation and disturbance of which certain evidence has been recognized, is subsequent to the deposition of the Catskill division, and even the coal formation, as it has disturbed all preëxisting rocks in New-York east of the Delaware; and the bending and wrinkling of the coal formation in Pennsylvania, Maryland and Virginia, is supposed to belong to this period. Its geological era is supposed to have been between the epochs of the coal formation and new red sandstone. This disturbance seems to have produced very marked effects in all the preëxisting rocks, and particularly in the Highlands, the Hudson valley and its southern extension, the Mamakating and Walkill valleys, and still further along the "Great valley" leading into Virginia and Tennessee.

5. The next period of disturbance seems to have been at the end of the deposition of the Long-island division, by which its strata were disturbed before the drift and quaternary were deposited. This may, very possibly, have been at the time of the eruptions of the trappean rocks; though we have no evidence, except that they belong to about the same geological period.

6. Another period was between the drift and quaternary periods, by which the land in mass, and retaining its configuration, was partially elevated to about the level of the quaternary formations. (Vide discussions on the drift.)

7. The last period of elevation seems to have been after the deposition of the quaternary system, by which a large portion of our country has been elevated above the waters of the ocean some hundred feet. (Vide discussions on pp. 148, 157, etc.)

(C). *Periods of metamorphic agency.*

This is a subject of much difficulty, and on which there is as yet little definite knowledge. The following remarks may afford some glimmerings of light to those who may investigate this subject, which is *one* of the *many* important geological problems.

It has been observed that where rocks have been most modified by metamorphic agency, they are near granitic, sienitic, trappean, quartzose and metalliferous protrusions, masses, dykes and veins.

1. It has been observed in the First geological district, that the trappean rocks intersect by

dykes, and are interlaminated with, all the rocks in the geological series until after the formation of the red sandstone of New-Jersey; and no traces of the intrusion of this rock are found in any of the strata of a later period. It is hence inferred that the trappean injections took place between the periods of the red sandstone of Rockland county and New-Jersey, and the Long-island division. The trappean injections seem to have produced great and marked changes in the rocks in Westchester, Rockland, Orange and Putnam counties, and more particularly in the limestones. These changes cannot, in all the localities, be referred to the trap alone, as augitic, granitic and sienitic rocks of a preceding era are also associated in many places, and in these latter cases the metamorphic changes and development of crystallized minerals are much more marked.

2. The next older series of injections among the rocks, that seems to have produced metamorphic changes, is that of the quartz veins. These traverse the gneiss, granite, and all the rocks up to the period of the newer strata of the Ontario division, but have not been observed traversing any of the rocks of a more recent date. This period seems to have been that in which most of the metamorphic changes were made in the rocks of the Champlain and Ontario divisions in the Hudson valley, but which had *been broken up* before the deposition of the limestones of the Helderberg division.

3. Another and perhaps more than one period of metamorphic action, preceded the last, and seems to have been produced by the protrusion and injection of granite and sienitic and augitic rocks. These rocks are not ascertained to have been more recent than the deposition of the limestones of the Champlain division, but appear to belong to the epoch immediately preceding the slates and grits of the Champlain division, since they have altered the pre-existing rocks where they came in contact up to that time; but we find no traces of such changes in any of the more recent rocks. This period seems to be that at which the white and red limestones of Orange, Putnam, Rockland and Washington counties, in New-York, and of Sussex county in New-Jersey, were brought to a metamorphic form, perhaps heightened by subsequent periods.

4. Another period of the protrusion and intrusion of granite, seems to have been that of the *transverse upheaves in a west-northwest and south-southeast direction;* as beds and veins, and intertruded masses of these rocks, are far more numerous along and near the lines of these transverse axes of disturbance than elsewhere, and the rocks along these lines are more altered, and loaded with interesting minerals.

The *period* of this elevation is *not ascertained.* It is *inferred* to have preceded the red sandstone of Rockland and New-Jersey, as these strata rest nearly undisturbed on rocks of this era near Stony point; *and to have been more recent than the newest rocks of the Champlain division,* as they are all deranged by it. It is also thought *probable* that it is more recent than the rocks of the Catskill division, as they appear to have been fractured and slightly deranged by the transverse upheave, but it is not demonstrated. It is thought *not improbable* that the transverse upheave was contemporaneous with that succeeding the coal formation, which affected the rocks so much along the great axes, or series of parallel axes,

from Tennessee through Georgia, the Carolinas, Virginia, Maryland, Pennsylvania, New-Jersey, New-York, Connecticut, Massachusetts, Vermont, New-Hampshire, and so on to Canada, and producing the transverse strata, and some of the echelon movements and lateral displacements that have been alluded to in various places in this volume, intruding granite among preëxisting rocks, and modifying them greatly in character. There is already sufficient known on this subject to render it an interesting one for discussion, but this volume is already swelled to an unreasonable size, and the above paragraphs contain the deductions from the facts.

4. Cause of disturbances and changes of characters.

The elevation of rocks to an inclined position, different from that in which they were formed; the elevation of islands and continents above the level of the sea, below which they were once buried; the contortions, wrinkling, and folding of strata, and the elevation of mountain chains in former times; and the grrdual changes of level with reference to the sea which are now in progress on parts of the earth's surface, have been referred to various causes, such as, 1st. An upheaving force, from the formation of steam and other elastic vapors in a high state of tension; 2d. The contraction of the earth by secular refrigeration, and the plications and foldings necessarily resulting from the solidified exterior collapsing upon the contracted nucleus by diminished temperature; 3d. The undulatory action of the fluid interior, combined with a tangential force.

These causes may all be true, and are perhaps sufficient to account for the facts. I may, however, be pardoned for suggesting an additional cause for the lateral tangential force, in connection with that arising from collapse of the exterior.

It is well known that the folded, crumpled, wrinkled, and inverted rocks of western Massachusetts and eastern New-York, extend from Canada on the north, through Vermont, New-York, Massachusetts, New-Jersey, Pennsylvania, Maryland, Virginia and Carolina, into Tennessee, and how much farther on this continent or on others, we are not *certain;* but the continuation of this on a great circle of the earth, would pass through some other systems of elevation. Leaving these out of consideration, it is evident that the cause that has simultaneously acted over the country from Canada to Tennessee, and that has acted *repeatedly* along the same line, producing the same effects, raising the strata into undulations, crumpling them, and finally pitching them all over in "folded axes," so as to give to all an easterly dip in the more easterly ranges, must have been a general one.* The rocks seem to have been slidden laterally, wrinkled up, and folded over and crushed together, as described in various places in this volume when treating of the Champlain division, Taconic rocks, etc.;

* Professor Hitchcock has given many developments on this subject (Vide Geological Report of Massachusetts, 1841, pp. 474, 478, 574, 575); and Professors H. D. and W. B. Rodgers, of Pennsylvania and Virginia, in their geological reports and memoirs. I have not their works at hand, and do not, therefore, here give references to them. The discussions on this subject in New-York may be seen on page 381.

and the polished surfaces of fissures, the shivered glazed slate, with all its fragments glazed as if rubbed over each other, and the newer pitching under more ancient rocks, lead to the conclusion that *lateral* motion has been produced by some cause.

1. It is generally admitted that the earth is in the state of a cooling body; at least, that it has a mean temperature on its surface much higher than that of the regions of space in which it performs its revolutions around the sun; that the interior of the earth is more heated than the exterior, and that it loses more caloric by radiation than it receives from the sun; in all which respects it is in the state of a cooling body. 2. Cooling bodies diminish in volume. 3. Bodies revolving on axes, if they diminish in diameter, increase in their velocities of rotation. Applying these principles to the earth, if the earth has increased in its velocity of rotation, either gradually or paroxysmally, the ocean, being a fluid, would not, in consequence of its inertia, immediately partake of this increased velocity; and as the earth revolves from west to east, a current of greater or less strength would set to the westward over the whole ocean, but strongest at the equator. So also with the solid mass of the exterior of the globe; its inertia would also tend to cause it to press to the westward with a power depending on its mass and its increased velocity of rotation, and if there were lines at which yielding could take place, slight motion might thus be expected to be produced, and effects on strata such as we see, would be the natural result of such causes.

If the interior of the earth be fluid, or partially so, and the solid exterior of the earth floating as it were upon it, any change of the velocity of rotation might be expected to produce still stronger effects, and changes of longitude of masses of the earth's surface be effected, such as we see evidences of in the crumpled, wrinkled and folded strata, which, if laid out (developed in a mathematical sense), would occupy much wider areas than they do at present.

The above is suggested as a possible, perhaps a probable, cause of the folding of the strata of the eastern part of the United States, in connection with the tangential force, or lateral thrust, arising from secular refrigeration, and consequent contraction of the earth, and from subsidence of portions of the earth's surface, such as that described by Darwin and Dana in the South Pacific, where sixteen millions of square miles area are gradually sinking, and also that of Greenland, which is settling below the water level.

It may be seen from what precedes in this volume, that most of the phenomena of physical geology may be referred to the effects of *caloric*, *gravitation*, and of the *rotation of the earth on its axis*.

If we suppose that there may have been variations in the length of our day, and if those variations occurred paroxysmally, the change in the velocity of the revolving system would, in consequence of its *inertia*, have a *tendency* to a retrograde or westwardly motion, until it should have acquired the increased velocity. The materials on the exterior portions of the mass of the earth would, therefore, press westwardly with a force proportioned to the increased velocity of the system and its mass; and if the solidified materials of the earth yielded along the lines of least resistance, changes of longitude of points on the surface must have been

effected; such as we see have been produced in the crumpled strata of the Apalachian chain, and in its continuation through and across the Hudson valley, the Green mountains, etc.; and as the points on the surface would be more affected than those nearer the centre of the revolving system, the wrinkles and folds of the strata would all have a tendency to fall over to the westward, giving an eastwardly dip.

If the changes of diameter of the earth, and consequently of the day, have been *secular* and not *paroxysmal*, the same *principles* would hold true, but the effects would necessarily be *less marked*.

We have no evidences of *changes of longitude* or of the *length of the day during the historical era;* but we have GEOLOGICAL *evidences* of changes of longitude on many parts of the earth's surface, in the wrinkling, crumpling and crushing of strata, the elevation of extensive mountain ranges, and the lateral heaves of transverse joints throwing the strata, and even the hills and mountains, in echelon. We have also evidences of stronger currents having existed in the ocean at particular periods than at others.

All these effects may be referred to the secular refrigeration of the globe, collapse of the exterior upon the interior, either paroxysmal or secular, diminishing the mean diameter, though often elevating portions of the earth above its former relative level; and also a lateral tangential force acting like that by collapse, only always in a westward direction.

It has been ascertained that the day has not varied in length a three hundredth of a centesimal second during the last two thousand years, and we have no geological evidence of any change during more than four thousand years; and all the changes that are as yet capable of being rendered at all certain, date back to periods far—*far* more remote.

Supposing a diminished radius of the earth corresponding to one three hundredth part of a second variation in the length of the day, the westward daily tendency from altered velocity would be so small as to be supposed unworthy of consideration; but it is to be observed, that this inertia acts *continually*, until the moving mass acquires the increased velocity, and in the course of time, the strata being supposed to yield along the lines of least resistance, the changes of longitude on points of the moving mass might be expected to become manifest.

M. Laplace has estimated the influence that the planetary bodies would have upon the length of our day, and shown that it would amount to only a few minutes in many millions of years; but I believe that the influence of refrigeration and contraction has not yet been calculated, and it is a subject worthy of investigation by some of our mathematicians.

APPENDIX.

ADDENDA TO THE ALLUVIAL DIVISION.

Land Slide.

A destructive land slide at Troy, Rensselaer county, was described on pp. 33, 35, of this volume, as having occurred January 1st, 1837. A slide at the same locality, and still more destructive of life and property, occurred on the afternoon of February 17th, 1843. Ten dwellings were crushed and buried beneath the moving avalanche, and from thirty to forty persons are supposed to have been destroyed. The cause of the slide seems to have been the same as those of 1836 and 1837, at the same place, viz: 1st. Undermining of the hill, to get earth for filling in the streets and grounds in the lower part of the city; 2d. The action of water accumulated in the sand and gravel beds above the clay, and in the fissures of partial breaks through the clay beds, rendering them slippery, and acting partially by hydrostatic pressure; 3d. The yielding nature of the gravel beds underlying the clay beds, and which had been partially removed, leaving the superincumbent masses but slightly supported. The main masses of materials of this hill are as follows:

1. Sand and gravel beds extending from the top of the hill to a depth of thirty or forty feet.
2. Greyish clay, containing clay stones of various forms, composed of clay indurated by carbonate of lime.
3. Blue clay, very fine and saponaceous.
4. Gravel and pebble beds down to the lowest level excavated: sixty to seventy feet.

The following, from the "Troy Budget," of February 18th, 1843, and from the "Troy Whig," of the same date, gives some of the particulars of the event:

"The distance from the commencement of the slide to the outer edge of the deposit of earth which it has left, is not far from two hundred yards, the earth having slidden more than five hundred feet over a dead level after it reached the bottom of the hill. The soil being a remarkably unctuous blue clay, is doubtless the cause of the extraordinary space which the slide covered. The slide commenced about one hundred yards east of Fifth-street, and its southern extremity first encountered two houses adjoining each other on the east side of the street, both of which it destroyed.

"The centre of the slide was then precipitated upon the head of Washington-street, overwhelming the buildings on both sides, except one dwelling at the corner of Hill and Washington-streets, which was partially destroyed. The number of houses destroyed on Washington-street was eight. The slide passed down Washington to Hill-street, which it crossed, and proceeding a few yards beyond, it was finally arrested."

The breadth of the slide, just above where it crossed the first street, is two hundred and ninety paces; at the next street below, one hundred and ninety paces; and from the top of the bank, to where the slide reached, is about five hundred yards, as estimated by the eye.

Fifth-street, over a length of about ninety yards, was entirely overwhelmed by the avalanche, and has not been reöpened; and all the space between that and Hill-street is covered by a confused mass of hillocks of clay and gravel, twenty or thirty feet deep in many places.

The clay in laminated masses exhibits its laminæ inclined to every point of the compass, and making all possible angles of dip, presenting the same marks of confusion that is so frequently witnessed among the slate rocks of the Hudson valley, where they have been broken up, intersecting axes of disturbance. After the progressive motion of the avalanche had ceased, so far as the *eye* could perceive, the mass of earth continued to heave and roll in places, by the lateral thrust of the mass pressing onward and causing the clay to slip and burst up, forming small hills.

The surface of slidden earth covers several acres; and now, more than seven months after the slide, it is still a mass of irregular ragged hillocks, showing the laminæ of clay dipping in every direction. Several days after the preceding slide, another nearly as extensive occurred, within a few rods of the former.

"About half past five o'clock yesterday afternoon (February 21st), another slide occurred immediately on the south of the avalanche of the 17th. Its movement was witnessed by many, and was at first so slow that any one within its reach could easily have escaped."

"The woodshed attached to a dwelling at the base of the hill on the south of the avalanche was carried away, and the house had a narrow escape.

"The amount of earth brought down by this slide is not much surpassed by that of Friday (17th). A large proportion of the former deposit was moved forward by the last slide about fifty feet.

"*P. S.* 12 M. *Feb.* 22*d.* The earth has moved considerable since last evening, making, we think, the aggregate of the last slide equal in amount to the first. The hill at this time presents a peculiarly interesting appearance. Besides the mass that has found a resting place on the level below, a huge mass, an acre perhaps, has separated from the hill and sunk about fifty feet, and slidden forward perhaps one hundred or more, leaving a wide and deep chasm between, from the side of which water rushed in powerful streams all night, from two holes in the gravel beds above the clay. The apertures are two or three feet in diameter; and some adventurous persons who have climbed within a few feet of them, say they penetrate far into the bosom of the hill."*

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* Troy Budget, February 27, 1843.

I have been much interested in the examination of the locality of this slide. The earth has cracked and crumbled, and slid down until a great part of the depth of the gulf between the hill and the mass that has partly slidden down is filled up. It is still, perhaps, fifty feet deep.

The materials are almost every day sliding down in small masses into this chasm. Many cracks may be seen on the hill-side south of the slide, where the earth has settled a few inches to a foot; and there is a strong probability of a slide occurring there at any time, though more probably in the winter. The ground from which the slides have occurred shows an area of four or five acres, from which the earth has more or less slidden down, and is encircled by a vertical cliff of gravel and sand beds twenty to forty feet high, and a slope of debris of seventy to eighty more, below which the clay and gravel hills of the slidden earth begin and extend near three hundred yards.

The portion of the hill north of the slide will now be more likely to slip than it was, since it has no longer any support on the south, and it seems to have settled some years ago several feet. Should this mass be undermined by digging, it will almost certainly slip. Great destruction would ensue, as the streets below are densely settled.

Bones of the Mastodon.

Bones of this animal are now (September 16th, 1843) being disinterred from the marl underlying peat in a marsh in Orange county. The bones of this animal and the fossil elephant are very common in the peat bogs of Orange and Ulster. They can be found by using a long iron rod, and thrusting it down through the peat. A person will readily learn to distinguish by the *feel*, when the rod strikes a log, a rock, a bone, or gravel or sand.

Supplementary Remarks on the Drift.

Since the last of the manuscript of this volume was handed to the publishers, I have first seen the volume containing the "Transactions of the Association of American Geologists;" and in that, in the memoir on drift, by Prof. Hitchcock, is the following paragraph:

"Mr. M'Laren has recently suggested an ingenious amalgamation of the iceberg theory of Mr. Lyell, with the glazier theory of Agassiz. He has rendered it very probable, that if most of the present continents of the globe were beneath the ocean, there would exist a broad westerly current between the tropics, and two easterly currents between the tropics and the poles. Such he supposes to have been the state of the northern hemisphere during the glacial period. He also supposes with Agassiz, that during the same time there was a vast accumulation of ice around the north pole; which, upon the return of heat, would send off currents southerly; and these meeting with the easterly currents, the result would be a current compounded of the two forces; that is, a southerly one, the very direction that seems to have been generally taken by drift over the whole northern hemisphere."*

* Transactions of the Association of American Geologists, 1843, p. 218.

It seems from the above, that M'Laren has advocated views *somewhat* similar to *some* of those in this volume, on the influence of polar and equatorial currents in the distribution of the drift, and his conclusions must have been prior to mine. I may here be permitted to say, however, that my conclusions were arrived at entirely independently, and from a review of the various facts; finding that some *general* cause affecting the *earth* was necessary to a solution of the problem of the drift, and without any suspicion that any other individual had an idea of referring the phenomena of the drift to such a cause, with the exception of a suggestion by Mr. Redfield, which has been acknowledged. It is another of the many examples on record, that in the progress of knowledge, various persons entirely independently arrive at the same conclusions, or make the same discoveries.

Discovery of a new Cave.

A cave has been mentioned as having been discovered in Schoharie county in 1842 (Vide page 80). It is called "Howe's cave," and "Otsgarage cavern." It is situated about four miles from Schoharie court-house, in Schoharie county. The proprietor has it now ready for the examination of all who wish to see this natural curiosity. It has been explored, it is supposed, to a distance of seven miles, and it seems to extend farther. Stalactites, stalagmites, and "festoons" of stalactitic drapery occur in the greatest abundance.

A view of the entrance to the cave may be seen on Plate 45. The cave is in the limestone of the Helderberg division. It is said to be the most extensive of any that has been explored in the United States, except the Mammoth cave in Kentucky.

Section across the Clove corrected.

The section across the Clove, fig. 5 of Plate 13, does not show exactly the position and order of the rocks (Vide note on page 363), as has been more recently ascertained. The sections figs. 182 of Plate 44 are believed to give the true position and order of superposition, where they are least deranged.

Transverse Axis.

The transverse axis that crosses Constitution island, and near the Cascade in the vicinity of West-Point (Vide p. 549, 622), is thought to be probably the same that crosses the north end of Skunnemunk mountain.

Axis and valley of elevation, &c.

An axis of elevation may be seen near West-Point, about half a mile west. The anticlinal line passes through the valley west of Fort Putnam, which is a valley of elevation. My

attention was called to this fact by Prof. Bailey of West-Point. The veins, interlaminations, beds and masses of granite and sienite, and also of augite and hornblende, with the effects they have produced on the contiguous rocks near West-Point, are well worth the attention of the *geologist*, as well as the *student* of geology. Although I have spent twelve years at West-Point, and during most of that time was an ardent explorer of the mineralogy and geology of the Highlands for ten miles around, every visit of exploration reveals new and interesting facts.

Quarries.

The location recommended for a quarry on Stony point, above Coldsprings, which, as distinguished from Stony point in Rockland county, has been called Quarry point (Vide pp. 527 and 528), has been opened, and furnishes a beautiful building stone. The locations recommended on Stony point in Rockland county, on Waggon's islands, on the north shore of the Horserace, and other points in the Highlands, will yield also an inexhaustible supply of beautiful and indestructible building materials.

On the variation in the length of our day, by a variation in the earth's diameter.

The times of rotation, velocities, etc., may easily be calculated approximatively from the proportions, $\frac{1}{r^4} : \frac{1}{r'^4} :: v : v' :: t : t'$;

whence $\frac{t'}{r^4} = \frac{t}{r'^4}$, and $t' = \frac{tr^4}{r'^4}$.

v and v' being the velocities of rotation,
r and r' " radii of the sphere,
t and t' " times of rotation:

If $r = 3956$ miles, $r' = 3955$ miles, and $t = 24$ hours; then,

$$t' = \frac{24 \times (3956)^4}{(3955)^4} = \frac{24 \times 244920496804096}{244672945705125} = \frac{5878091923298304}{244672945705125} = \overset{\text{H.}}{24}\ 1'\ 12''\ 42'''.2.$$

The variation of the radius of the earth to the amount of one mile, would, according to the above, cause a variation of the time of a revolution on its axis, or of the length of the day, of about $1\frac{1}{5}$ minutes, or, more exactly, of $1'\ 12''\ 42'''.2 + .$

The above formula is not strictly an accurate one to express the conditions of the earth as a revolving body; for it is not a sphere, and by an alteration of its radius, its density would not remain the same, and some other conditions would cause some slight variations; but the above expression is believed to be the most simple that gives an approximatively true result of such changes as have been considered.

It is hoped that Prof. Hackley, of Columbia College, New-York, and Lieut. Roberts, of the U. S. Military Academy at West-Point, will enter into a mathematical investigation of the influence of a diminished diameter of the earth upon the length of our day, considering its spheroidal form, variable density, etc.; and whether the influence of the planets in varying the length of the day, infinitesimal as it is, acts as a compensation for the effects of refrigeration, and the removal of materials from higher to lower levels by alluvial action.

BIBLIOTHECA
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ERRATA.

77. Put quotation marks at end of fifth line from the top.
78. Erase "and," in the third line, and for "abounds" read *abound.*
216. In third paragraph, third line, erase "*as,*" before the word "*established.*"
216. In ("6") for "speroid," read *spheroid.*
218. After the first word of the note *, insert *present positions of the.*
221. Insert between "polar" and "currents," the words *and equatorial,* in the caption.
222. Nineteenth line from top, for "caused," read *causes.*
264. Ninth line, for "surrounded," read *rounded.*
280. Note, for "Pompey's hook," read *Bompey's hook.*
297. Note, for "Lickinep," read *Licking.*
311. In No. 45, for "Aukville," read *Arkville.*
328. Eleventh line, after "county," insert *has.*
331. Fourth line from bottom, for "south-southeast," read *east-southeast.*
335. Last line, for "ore," read *sand.*
339. Fourth line, for "favosites," read *favosite.*
351. Fourth line of ‡ note, for "strata," read *strike.*
367. Twelfth line from top, for "tilled," read *tilted.*
385. Bottom line, erase the period, and for "The," read *the.*
624. Seventh line from bottom, for "axis" read *axes.*
627. Twelfth line from bottom, for "distance," read *distances.*
635. Tenth line from top, before "ninety," insert *one hundred and.*
635. Sixteenth line from top, before "intersecting," insert *by.*

EXPLANATION OF THE PLATES.

PLATE I.

A topographical and geological map of Long and Staten islands, and of the Island of New-York.

PLATE II.

Fig. 1. Topographical sketch of Sand's point and vicinity.
2. Section of the above, across the beach, showing the marsh mud under the beach.
3. Topographical sketch of Oysterpond point and vicinity.
4. Shows the position of the drift deposits, by a section.
5. Shows the boulders on the beach and around the marsh, washed out by the surf.

PLATE III.

Fig. 1. Geological section on the island of New-York, parallel to the strike from Fiftieth-street to Brooklyn heights.
2. The same, perpendicular to the strike across the island, showing the depth to the rock.
3. Section of the Hudson slate rocks, contortion, etc.: J. Wickmin's quarry, Lansingburgh.

PLATE IV.

Fig. 1. Diagram illustrating the position of the materials of the east part of Long island.
2. Section of the cliffs at Montauk point, Long island.
3. Section half a mile west of Brown's point, L. I.
4. Section 200 yards south of the same.
5, and 6. Sections near the same, exposed by encroachments of the sea.
7. Section 250 yards south, arched and unconformable strata, exposed by the storm of 12th October, 1836.
8. Section three miles and a half west of Oysterpond point.
9. Land-slide one mile and a half west of Brown's point.

Fig. 10. Land-slide on the west side of West Neck, Coldspring harbor.
11. Section of a clay bed, etc. at Coram.
12. A fault in clay and sand beds, at West neck.
13. Land-slide, and contorted strata of sand and clay, West neck.
14. Irregular deposition of strata.
15. Unconformable strata at Brown's point.
16. Section along the north-northwest side of Lloyd's neck.

PLATE V.

Fig. 1. Thick gneiss, bedded and stratified: Phillip's quarry, one mile and a half east-northeast of West-Point.
2. Marble lying on granite, at Sparta, by the brick-yard.
3. Section at Tompkin's quarries, one mile above Stony point, showing the junction of talcose slate, with limestone and talcy limestone glazed with anthracite.
4. Columnar and mural escarpment of trap and sandstone near Verdrietje hook.
5. Columnar trap, with a dyke and interstratified mass of trap in sandstone, one and a half or two miles south of Haverstraw.
6. Palisades, and slope of debris.
7. Section of the Denny iron ore bed, capped by gneiss: Phillipstown, Putnam county.
8. Section of the same, 200 yards south of the preceding. Branches and strings from the mass reach the surface.
9. Section of the Forest of Dean iron mine, Cornwall, Orange county.
10. Section of the Patterson and other ore beds, Monroe, Orange county.
11. Trap dykes in white limestone, Duck-cedar pond, Orange county.
11′. Shewing the lateral heaves by faults, at the same locality.
11″. Topographical sketch of the vicinity.
12. Section of the Simewog vein of magnetic iron ore: Southeast, Putnam county.
13. Section of the Upper clove, from Skunnemunk to the Highlands.
14. Section of Townsend's ore bed, near the preceding section, Orange county.

PLATE VI.

Fig. 1. Section of some of the Catskill mountain rocks, at the stone bridge four or five miles east of Durham, Greene county.
2. Section of the same rocks, at Stratton's falls, Roxbury, Delaware county.
3, and 4. Showing the water-lines of deposition, or oblique lamination of sandstones in the Catskill mountain rocks.
5, and 6. Showing the same in the calciferous sandstone near Whitehall, Washington county.
7. Section from the Shawangunk mountain to the "Coal mine," on the Sandberg mountain, Sullivan county.

PLATE VII.

Fig. 1. Section of the Helderberg and water limestones, Rosendale, Ulster county.
2. Section of the limestones pitching against the Shawangunk grit, Ulster county.
3. The same as they appear to the eye.
4. The same with faults, as though the limestone and grit were interstratified.
5. Helderberg limestone and cement beds at White's quarries. Faults and contortions.
6. Section at Wilbur, showing similar appearances.
7. Section at Wallkill falls, Dashville, Ulster county.
8. Arched strata at Dashville.
8′. Magnified illustration of 8, showing the cracks formed in bending.
9. Section of the Helderberg limestone and Hudson river slates, unconformable, between Glasco and the Great falls of Esopus creek, Ulster county.

PLATE VIII.

Fig. 1, 2, 3. Sections of the Helderberg limestone and Hudson river slate, unconformable, and the superposition of the quaternary and alluvial, Greene county.
4. Section at High falls, Rondout, Ulster county.
5. Cement beds, confused stratification, near Rondout.
6. Fault at the falls of Esopus creek.
7. Reversed limestones at High rock, one mile northwest of Kingston point, Ulster county.
8. Faults of the limestone on the ridges between Hurley and Kingston.
9. Showing the position of the same rocks as the preceding, on the south side of the anticlinal axis.
10. Fault and anticlinal axis. Transverse section across the north end of the lake at Marbletown.

PLATE IX.

Contortions of the Hudson slate, to wit:

Fig. 1 and 2. One mile and a half below Croft's point, Columbia county.
3. One mile and three quarters below Croft's point.
4. On the point opposite the head of the island, two or three miles below Croft's point.
5. One mile and a quarter below Rhinebeck landing.
6 and 7. Opposite the Light-house, Germantown, Columbia county.
8. One mile and a quarter below Rhinebeck landing, Dutchess county.
9. At the point below Rhinebeck landing.
10. ————.
11. Right bank of Rondout-kill, Eddyville, Ulster county.

Fig. 12. One mile and a half below Croft's point. A fault.
13 and 14. ———
15. Contortions of the Helderberg limestone and cement beds, two miles above Rosendale, on the right bank of the Rondout.
16, 17, 18, 19, 20, 21. Examples of contortion of the Helderberg limestone at various localities.

PLATE X.

Fig. 1. Slate intersected by a horizontal seam (Briggs).
2. Curious contortions.
3. Oblique strata of the Hudson river slate.
4. The same, between Ancram iron-works and lead mine.
5. The same, between Jackson Corners and Clermont.
6. The same, forty rods east of Lewis's landing.
7 and 8. The same, and slaty layers interstratified with grit rocks, one mile below Rhinebeck landing.
9. The same, contorted, one mile and a quarter below Rhinebeck landing.
10. The same, a little below Rhinebeck landing.
11. Horizontal section of contorted and folded strata, 100 yards below Lower Redhook landing.
12. Contorted strata, Lansingburgh.
13. Contorted lines in stratified metamorphic limestone, between Peekskill and Verplanck's point, Westchester county.
14. Contortions in slate, caused by nests and veins of quartz: Hillsdale slate quarries, Columbia county.

PLATE XI.

Contorted slate, to wit:

Fig. 1. One mile and a half northwest of Cohoes falls, Saratoga county.
2. Half a mile northwest of Visscher's ferry Saratoga county.
3. Two miles west of said ferry.
4. Half a mile west of said ferry.
5, 6, 7. Two miles east of Alexander's bridge, Saratoga county.
8, 9, 10, 11, 12, 13. At Saratoga lake, Snake hill.
14. Anticlinal and synclinal axes, half a mile west of Visscher's ferry.

PLATE XII.

Fig. 1. Section from the Noses on the Mohawk, to Summit four-corners in Schoharie county.
2, 3, 4. Contorted slate.
5. Arched and disrupted.
6 and 7. Slaty cleavage and strata.
8. Section across Lebanon valley.

PLATE XIII.

Fig. 1. Section from Troy to the Massachusetts line.
2. ———.
3. Section across the valley of Stone creek, Columbia county.
4. Section across New-Lebanon valley, through Middle Shaker Medical Garden. B.
5. Across the same valley, south of the South Shaker Family. B.
6. Section from Canaan four-corners to Austerlitz. C.

PLATE XIV.

Fig. 1. Section from Hillsdale to Egremont, Columbia county.
2. From Canaan to Whiting's pond.
3. From Austerlitz to Spencertown.
4 and 5. From Roya-hook to Peekskill, Westchester county.
6. From Canaan, Columbia county, to Massachusetts line.
7. From Verplanck's point to Cruger's point, Westchester county.

PLATE XV.

Fig. 1. Section from Lackawaxen creek to Port Jervis on the Delaware river, Sullivan and Orange counties.
2. From Port Jervis to Ellenville, along the canal.
3. From Ellenville to Newburgh.

PLATE XVI.

Fig. 1. Section from Hudson city to New-Lebanon, Columbia county.
2. From Wing's corners in the southeast part of Dutchess county, to Poughkeepsie.
3. From Hudson to the southeast corner of Canaan, Connecticut.

PLATE XVII.

Fig. 1. Section from the northeast corner of Austerlitz to Stockport on the Hudson river, Columbia county.

2. From the Massachusetts State line, to the city of Hudson.

3. From Johnstown to Taghkanick, and thence to Copake lake, Columbia county.

PLATE XVIII.

Fig. 1. Section from Poughkeepsie to Sharon, Connecticut.

2. From Poughkeepsie to Ameniaville.

3. From Fishkill across the Highlands to the Connecticut State line, on the road to Danbury.

PLATE XIX.

Fig. 1. Fossil found in a boulder at Schoharie, by J. GEBHARD junior.

PLATE XX.

Fig. 1. Fossil found at Schoharie, by J. GEBHARD junior.

PLATE XXI.

INFUSORIA.

The sketches on this plate were all made by Prof. Bailey of West Point, by means of a camera lucida eye-piece attached to Chevalier's horizontal and vertical microscope. In fig. 39 is shown a sketch of $\frac{1}{1000}$ths of a *millimetre*, magnified and drawn with the *same* combination of lenses, camera lucida, distance, &c. This being *equally magnified* with the drawings, will serve as a scale to determine the *absolute dimensions* of any of the objects. The highest power of the instrument was not used in getting the outlines, as it would have given figures inconveniently large. The details were, however, occasionally corrected or confirmed, by the use of a higher power.*

Fig. 1. Desmidium Schwartzii, from a twisted portion of a filament.

2 and 3. Euastrum? two positions of same individual.

4 and 5. Euastrum? a larger variety of the same species as fig. 3.

5. shows the same in side view, the lower half being in a state of imperfect development.

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* Silliman's Journal, Vol. 41.

Fig. 6. Variety of fig. 3?

7. Five-armed variety of fig. 4.

8. a. b. Euastrum margaritiferum, a. b. different position of same individual.

9. a. b. Euastrum ——, a. b. two positions.

10. Euastrum ——.

11 and 12. Euastrum ——.

13. Euastrum ——.

14. Euastrum ——.

15. Xanthidium ——, a recent species from West Point.

16. a. b. Xanthidium ——, another species from West Point.

17. Arthrodesmus quadricaudatus.

18. a. b. Arthrodesmus cutus?

19. Micrasterias Tetras.

20. Micrasterias Boryana.

21. Micrasterias ——.

22. Euastrum rota?

23. Euastrum Crux-Melitensis?

24. Euastrum ——, possibly a young state of E. rota.

25. Euastrum ——.

26 and 27. 27 a. b. c. d. *Euastrum* ——, (Echinella oblonga of Greville?) a. b. two positions of same individual, c. d. smaller individuals.

28. a. b. Euastrum ——, two portions.

29. Euastrum ——.

30. Closterium lunula.

31. Closterium moniliferum.

32. Closterium trabecula?

33. Closterium digitus?

34. Closterium lineatum?

35. Closterium striolatum.

36. Closterium rostratum.

37. Closterium tenue?

38. Closterium ——.

39. Scale, each division of which represents $\frac{1}{100}$th of a millimetre magnified equally with the sketches.

PLATE XXII.

INFUSORIA.

The figures on this plate were all drawn by the aid of a camera lucida, by Prof. Bailey of West Point, "and to the same scale as was used in the plates of the first part of this sketch. That scale is shown in fig. 15, which represents $\frac{1}{1000}$ths of a millimetre, magnified equally with the drawings. In the sketches, *a* represents the side of the animal usually seen, *b*, the other side."†

Fig. 1. Pyxidicula operculata, fossil from Manchester, Mass.—fluviatile.

1. *a*. Pyxidicula operculata? fossil from Massachusetts.
2. *a*, *b*. Pyxidicula? Fossil in infusorial stratum at Richmond, Virginia.
3. Gaillonella moniliformis, recent, marine.
4. 4 *a*. Gaillonella aurichalcea, recent, fluviatile, at c is seen a globular joint.
4. *b*. Gaillonella aurichalcea? recent fluviatile.
*5. Gaillonella distans, recent and fossil, fluviatile.
*6. *a*, *b*. Gaillonella varians, recent and fossil, fluviatile.
7. *a*, *b*. Gaillonella sulcata. Fossil at Richmond, Va., recent, marine at Stonington, Conn. *a* jointed cylinder composed of several individuals; *b*, base of one of the joints.
8. Gaillonella? ——. Recent, brackish water of Hudson River at West Point.
9, 10. Actinocyclus. Fossil at Richmond, Va.
11. *a*, *b*. Actinocyclus. *a*, base; *b*, side view, showing the alternate elevations and depressions which cause the light and dark portions seen on *a*. Fossil at Richmond.
12. Coscinodiscus lineatus. Fossil in tertiary infusorial strata of Virginia, at Richmond, and on Rappahannock river.
13. Coscinodiscus patina. With the preceding.
14. Coscinodiscus radiatus. With the preceding.
15. Scale representing $\frac{1}{100}$ths of a millimetre, magnified equally with the sketches.
*16. *a*, *b*. Navicula viridis, recent and fossil, fluviatile, *c*, *c*, *c*, *c*, the orifices.
17. *a*, *b*. Navicula viridis, copied from Ehrenberg.
18. Navicula ——, marine, at Stonington, Connecticut.
19. Navicula ——, marine, with the preceding.
20. Navicula ——, fluviatile, West Point, &c.
21. *a*, *b*. Navicula striatula, fluviatile, recent and fossil.
22. Navicula ——, fossil at Richmond, Virginia.
*23. *a*, *b*. Navicula ——, fluviatile, recent and fossil.

---

† Silliman's Journal, Vol. 42.

*The species thus marked are the most common *fresh water species* that are fossil in the State of New-York. Others that accompany them will be describsd in the 3d part of this article on infusoria. Vide p. 237, in the supplement to the quaternary. J. W. B.

24. *a*, *b*. Navicula sigma? marine, Stonington.
25. *a*, *b*. Navicula ——, fossil at Richmond, Virginia.
*26. a, b, c. Eunotia arcus, fluviatile, recent and fossil. c, cross section.
27. *a*, *b*, *c*. Eunotia ——, brackish ditches, New-Jersey. c, cross section.
*28. Eunotia monodon,
*29. Eunotia diodon,
*30. Eunotia triodon,
*31. Eunotia tetraodon,
*32. Eunotia pentodon,
*33. Eunotia serra,
} fluviatile, recent and fossil.
34. Cocconeis ——, marine, Florida.
35. Bacillaria paradona, marine, Hudson river.
36. a, b. Bacillaria tabellaris,
37. a, b. Bacillaria tabellaris, full grown?
} fluviatile, recent and fossil.
38. Bacillaria ——, marine, at Stonington, Connecticut. Recent.
39. Tessella catena? marine, at Stonington, Connecticut. Recent.
40. Fragillaria pectinalis,
*41. Fragillaria bipunctata?
} fluviatile, recent and fossil.
*42. *a*, *b*. Meridion vernale, fluviatile recent and fossil in fragments.

PLATE XXIII.

Hudson slate and Taconic rocks.

Fig. 1. Section of the Indian-pond ore bed.
2. Section of the Amenia ore bed, Dutchess county.
3. Section at Leedsville mountain, Amenia.
4. Section of the Ancram lead mine, Columbia county.
5. Section of Bockee's and Bryan's lead mines, Dutchess county.
6. Lateral dislocations of limestone, Ghent, Columbia county.
7. Section south of Redrock, Columbia county. *a* and *b*. Interstratifications of slate and quartz. *c*. Slate permeated by quartz.
8. Section of the Stuyvesant quarries, Columbia county.

PLATE XXIV.

Hudson slate and Helderberg limestone.

Fig. 1. Contortion of slaty grits: Rogers's island, Columbia county.
2. Contorted strata at Great Neutenhook, Columbia county.
3. Section of various rocks at Great Neutenhook.
4. Slight faults in limestone of Becraft's mountain, Columbia county.
5. Section at the southeast part of Becraft's mountain.
6. Section at the same place, shewing the limestone and Hudson slate.

EXPLANATION OF PLATES.

PLATE XXV.

From the Hudson slate to the Catskill group.

Fig. 1 and 2. Faults in the Barnegate limestone, Barnegate, Dutchess county.
3. Section at Sharon springs, Schoharie county.
4. Section at High falls, Ulster county.
5. Section of the Helderberg series, Schoharie county.
6. Section from Esperance in Schoharie county, to Deep clove in Ulster county.
7. Section at Deep clove.
8. Section at Stone clove, Greene county.
9. Fossil plant stem in the Catskill mountain rocks, Durham, Greene county.

PLATE XXVI.

Hudson slates, Shawangunk grit, and Helderberg limestones.

Fig. 1. Section on the right bank of the Rondout, Ulster county.
2. Topographical sketch of the anticlinal axis at Two-ponds, Ulster county.
3. Section across the above axis at Two-ponds.
4. Section across the same axis, half a mile above Lawrenceville.
5. Across the same axis, at Lawrenceville.
6. Across the same, on the Shawangunk mountain.
7. Near the same axis, between Rochester and the Shawangunk mountain.

PLATE XXVII.

Quaternary.

Fig. 1. Section of a gravel bank near Hudson.
2. Topographical sketch of beach and marsh near Southold, L. I.
3. Section of the above.
4. Section on the west side of Newburgh bay, Orange county.
5. Section from Lower Redhook landing, east two miles, Dutchess county.
6. Section at Grassy point, Rockland county.
7. Section between the Hudson river and Norman's kill, Albany county.
8 and 9. Limestone and quaternary at Hurley, Ulster county.

PLATE XXVIII.

Primary to Quaternary.

Fig. 1. Section from Lake George in New-York, to Poultney in Vermont.
2. Section at Mr. Goulard's farm in Putnam, Washington county.
3. Section across the Twelve-mile marsh on Lake Champlain.
4. Topographical sketch of the Hudson from Barnegate to Fishkill, Dutchess county.

PLATE XXIX.

Fig. 1. Topographical sketch of the Hudson from Oakhill ferry in Columbia county, to Lower Redhook landing in Dutchess county.
2. A like sketch from Garrison's point to Hydepark.
3. Section of the Catskill mountain rocks in Sullivan county.

PLATE XXX.

Primary and Metamorphic.

Fig. 1 and 2. Contorted wrinkled limestone at Peekskill bay, Westchester county.
3. Plane and wrinkled limestone at the same place.
4. Topographical sketch of Sterling mines and vicinity.
5. Section across the above.
6. Sketch of a granite vein traversed by quartz veins.
7. Sketch of the extent of limestone on New-York island.

PLATE XXXI.

Quaternary.

Fig. 1, 2, 3. Sections of the gravel pits on the Patroon's creek, Albany county.
4. Section of the clay and sand beds on Arbor hill, Albany county.
5 and 8. Faults of the clay and sand beds at the same place.
6 and 7. Wrinkled clay beds wedged between plane ones: same place.
9. Section of striped blue clays: same place.

PLATE XXXII.

Alluvial.

Section of Ball's cave, Schoharie county.

PLATES XXXIII & XXXIV.

Geological sketch along the right and left banks of the Hudson river.

PLATE XXXV.

Sketch of the High-rock spring, Saratoga springs, Saratoga county.

PLATE XXXVI.

Erratic blocks, etc.

Fig. 1. Block of contorted hornblendic gneiss with granite veins, on the shore about north of Mr. Latham's Hotel, on Oysterpond point, Long island.

2. Block of hornblende slate, contorted, and containing contorted veins of red granite of a moderately fine grain, and a large forked vein of grey fine granite, on the shore north of Greenport, Long island.

3. Block of granite in the water north-northwest of Oysterpond point hotel, with a contorted vein of fissile hornblende slate.

4. Block of gneiss showing on oblique lamination like some of the sandstones, near the shore at Wading river, Long island.

5, 6, 7. Sketches of Snake hill, Saratoga lake, Saratoga county.

PLATE XXXVII

Drift.

Fig. 1, 2, 3. Drift scratches.

4. Granite boulder supported on pillars of crumbling limestone, at North-Salem, Westchester county.

PLATE XXXVIII.

Fig. 1. Section of Mount Bob in Columbia county, showing the Helderberg division: *a.* Blue limestone; *b.* Grey limestone; *c.* Fossiliferous limestone.

2. ————.

3. North end of Nuttenhook in Columbia county, showing the Calciferous group, etc.

4. Interstratification of limestone and slate at Rider's mills, Columbia county.

5. The same at the Kinderhook lake quarry.

6. Talcy slate and limestone in contact, north of Amenia, in Columbia county: *a.* Limestone; *b.* Slate; *c.* Contact.

7. Red slate with green veins.

Fig. 8. Section at the north end of Nuttenhook, Columbia county.
9. Contortion of limestone.
10. Apparent contortion across strata on the right bank of Catskill creek, a quarter of a mile below Madison corners, Greene county.
11. Contorted rocks one mile from Catskill, on the creek opposite Rouse's tannery, Greene county.
12. Contorted slate, one mile north of Snake hill, on the shore of Saratoga lake, Saratoga county.
13. Section at the Mineral spring three miles west of Athens, Greene county: *a*. Blue limestone; *b*. Fossiliferous limestone; *c*. Quaternary clays; *d*. Hudson slate group.
14. Section from Kaaterskill stone bridge to Catskill, Greene county. L. Helderberg limestones, blue, grey, and fossiliferous; M. Marcellus shales; S, S′. Hudson slate group; T′. Clays of the quaternary.

PLATE XXXIX.

Fig. 1. Redbridge lead mine, Ulster county: *a*. vein; *b*. Arched slate at fault; *c*. Shawangunk grit.
2. Section across the Shawangunk to the Redbridge coal mine: *a*. "Coal mine;" *b*. Fossiliferous grits; *c*. Limestone and Shawangunk grit; *d*. Lead mine.
3. Section across the Shawangunk mountain to Port Jervis, Orange county; *a*. Shawangunk grit; *b*. Red grit and slate; *c*. Dark slate with double cleavage; *e*. Limestone (Helderberg division); *f*. Quaternary; *g*. Dark shales and grits, almost trappean.
4. Bent strata next a fault on the right bank of the Delaware, four miles and a half below Halfway brook, below the mouth of the Lackawaxen.
5. Quaternary and drifts; Coxsackie, Greene county.
6. Waterlines of deposition in the quaternary at Coxsackie.
7. The same at East neck on Long island.
8. The same at Eaton's neck, Long island.

PLATE XL.

Fig. 1. Echelon hills of rock. (By Prof. Dewey, *Silliman's Journal*, Vol. 8, p. 11.)
2. Oolitic structure. (*Silliman's Journal*, Vol. 9, p. 19, pl. 2).
3. Contorted slate, two miles west of Vischer's ferry.
4. Bent slate, fifty rods below Alexander's bridge.
5. The same, above the bridge.
6. Bent slate on the Mohawk river.
7. Deposition layers, two miles west of Halfmoon.
8. The same, three miles west of Vischers quarry.
9. The same, half a mile east of Vischer's.
10. Vischer's quarry.

EXPLANATION OF PLATES.

PLATE XLI.

Young and Heron's map of part of Orange county (*Silliman's Journal*, Vol. 21, pp. 320, 321).

PLATE XLII.

INFUSORIA.

The figures of this plate were drawn by means of the camera lucida, and to the same scale as was used in Plates 21 and 22.

Fig. 1. Synedra ——. One group of frustules, with part of another, parasitic on aquatic plants in the Hudson River. *a*, fleshy base; *b*, fleshy projection at the summit. Brackish water.

2. Synedra ——. *a*, *b*, different positions. Fresh water, also fossil.

3. Podosphenia ? possibly a Gomphonema. Fresh water.

4. Gomphonema minutissimum. *a*, largest size; *b*, smaller individuals. Hudson river near West-Point.

5. Gomphonema ——, *a*. *b*, different positions; 6 *c*, sketch of a group of individuals with the branching pedicels.

6. Gomphonema acuminatum. *a*, *b*, different positions. Fresh water, also fossil.

7. Gomphonema ——. 7 *a*, another view of a frustule. Marine, Stonington, Conn.

8. Echinella flabellata, a single group. Fig. 8, *b*, a sketch of several groups slightly magnified, drawn from the living specimen. Marine, Stonington, Conn.

9. Echinella ——, a group parasitic on an aquatic plant. Fig. 9, *a*, *b*, different positions of a single frustule. Hudson river.

10. Cocconema ——, group supported on the branching pedicel. Hudson river.

11. Cocconema ——. *a*, *b*, two positions of an individual separated from its pedicel.

12. Achnanthes brevipes, several groups parasitic on a Conferva; *b*, a larger pair; *c*, back view. Stonington, Conn., Hudson river, &c.

13. Striatella arcuata. Marine, Stonington, Conn.

14. Naunema ——. *a*, *b*, two positions of the frustule separated from its tube. Marine, Staten Island, N. Y.

15. Naunema ——. *a*, frustule separate from its tube. Stonington, Conn.

16. Naunema ——. *a*, *b*, two positions of a single frustule. Stonington, Conn.

17. Naunema ——, group of frustules within their tube. West Point, N. Y.

17. *a*. Naunema ——, single frustule. West Point.

18, *a* to *d*. Spiculæ of Spongilla or fresh-water sponge.

19, *a*, *b*. Probably spiculæ of another species of Spongilla; *b*, group of three individuals.

Fig. 20. Amphidiscus rotula of Ehrenberg, probably derived from a Spongilli. Fossil at West-Point, near Boston, Wrentham, &c., also in South America.

21 to 23. Siliceous bodies of organic origin, found with fossil fresh-water infusoria.

24. Dictyocha fibula? Ehr. Common among fossil marine infusoria in the infusorial stratum of Virginia at Richmond and Rappahannock cliffs.

25. Fragment of the preceding.

26. Dictyocha speculum, Ehr., with the preceding.

27 and 28. Siliceous bodies, found with the preceding.

29. Binary, triangular, siliceous bodies, found with the preceding.

30 to 35. Siliceous spicula, etc. probably derived from marine sponges or Actinia, found with the preceding.

36. Scale showing $\frac{1}{100}$ths of a millimetre, magnified equally with the drawings.

PLATE XLIV.

Fig. 1. Section from Monticello, Sullivan county, to the Croton river, near Bull's bridge, in Westchester county.

2. Section from Forestburgh, Sullivan county, across Orange and Rockland counties to Tarrytown, Westchester county.

3. Section from Oneonta, on the Susquehannah, to Jones's Beach, Long island, across Delaware, Sullivan, Orange, Rockland, Westchester, and Queens counties.

PLATE XLV.

View of the entrance of Howe's cave, in Schoharie county.

PLATE XLVI.

Fig. 1. Section from Roxbury, Delaware county, to the Connecticut line (Vide line of section on the State map).

2. Section from Fallsburgh, Sullivan county, by the mouth of Murderer's creek, across Orange, Putnam, and Westchester counties, to the State line.

3. Section from the Catskill mountains, in Neversink, across Ulster, Dutchess, and Putnam counties, to the State line.



New York, 1872.

ical Surveys

Smith.

MAP OF

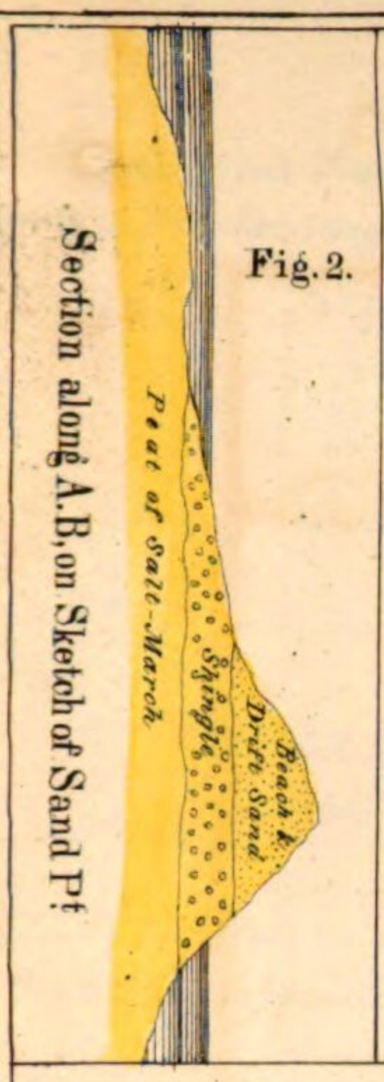
W-YORK

SLAND.

PLATE 2.

Alluvial Action.

Fig. 2.



Section along A.B. on Sketch of Sand Pt

Topographical Sketch of Sands Pt & Vicinity.

Fig. 1.

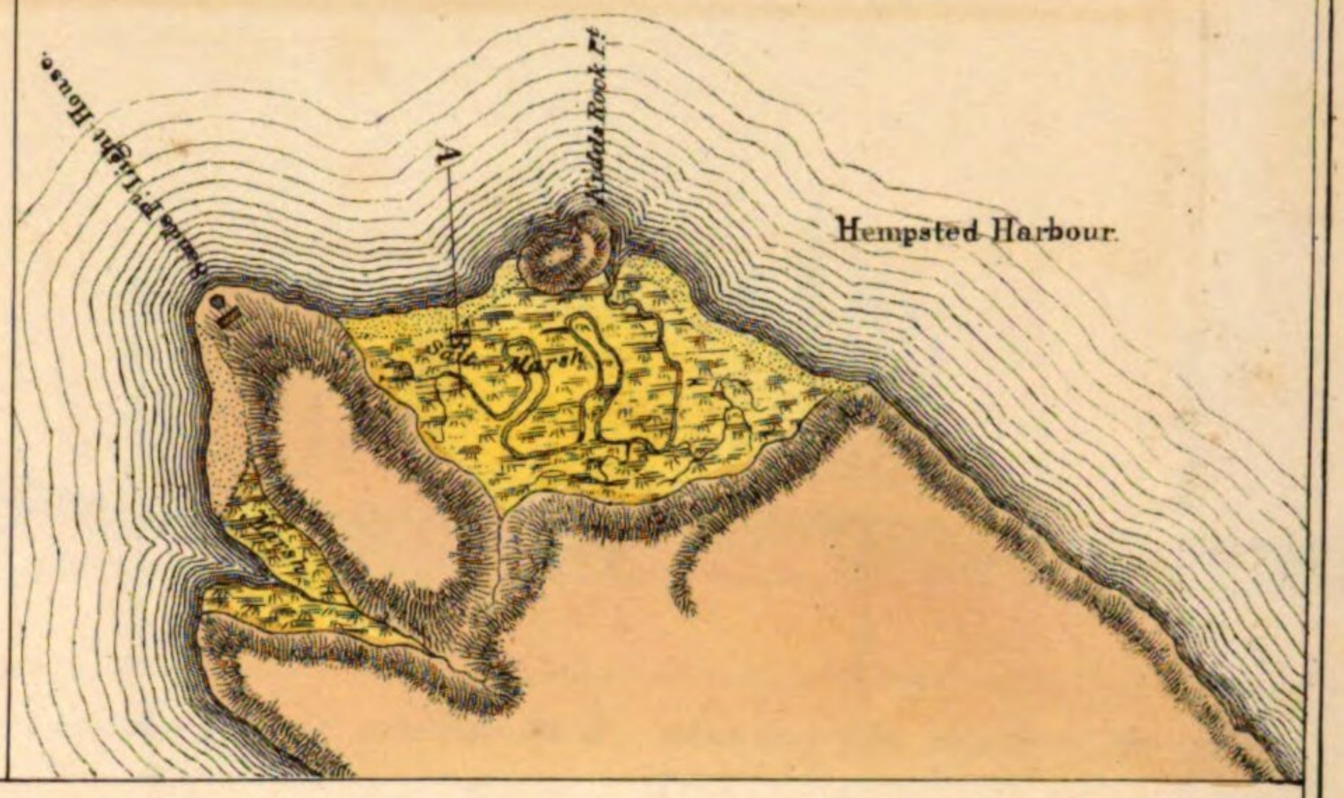


Fig. 4.

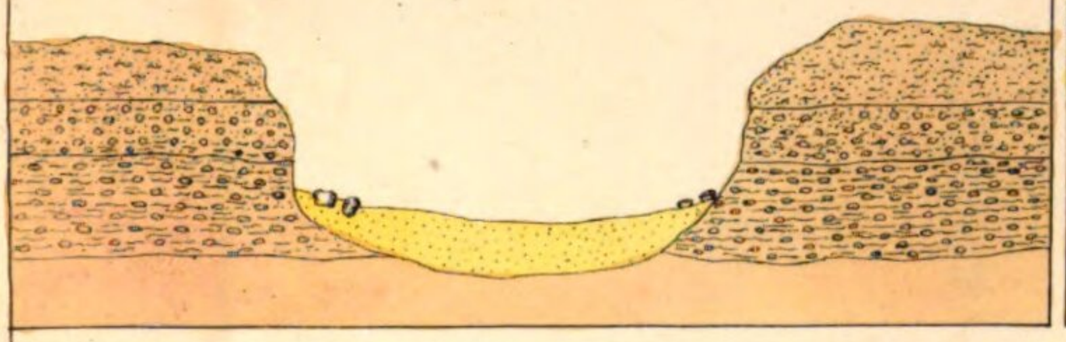


Fig. 5.

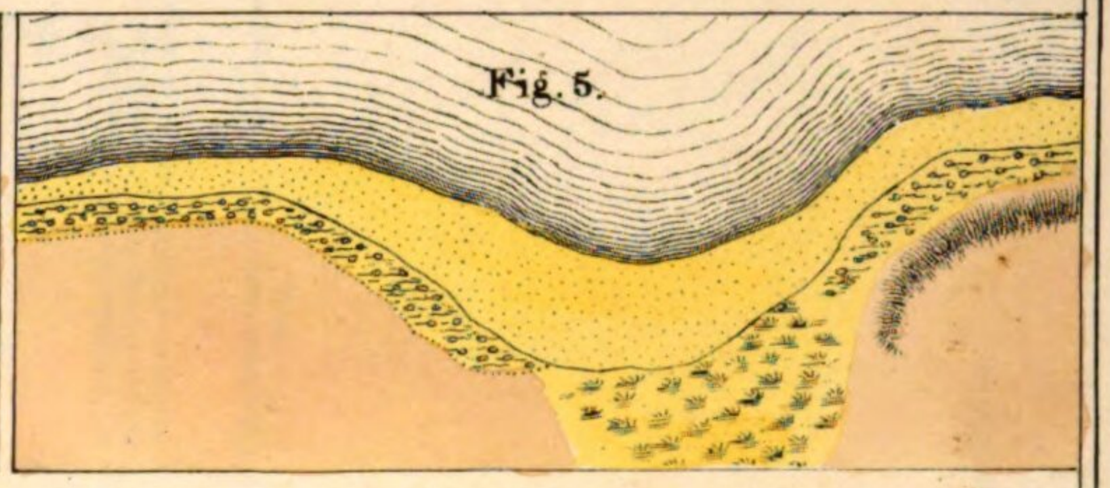
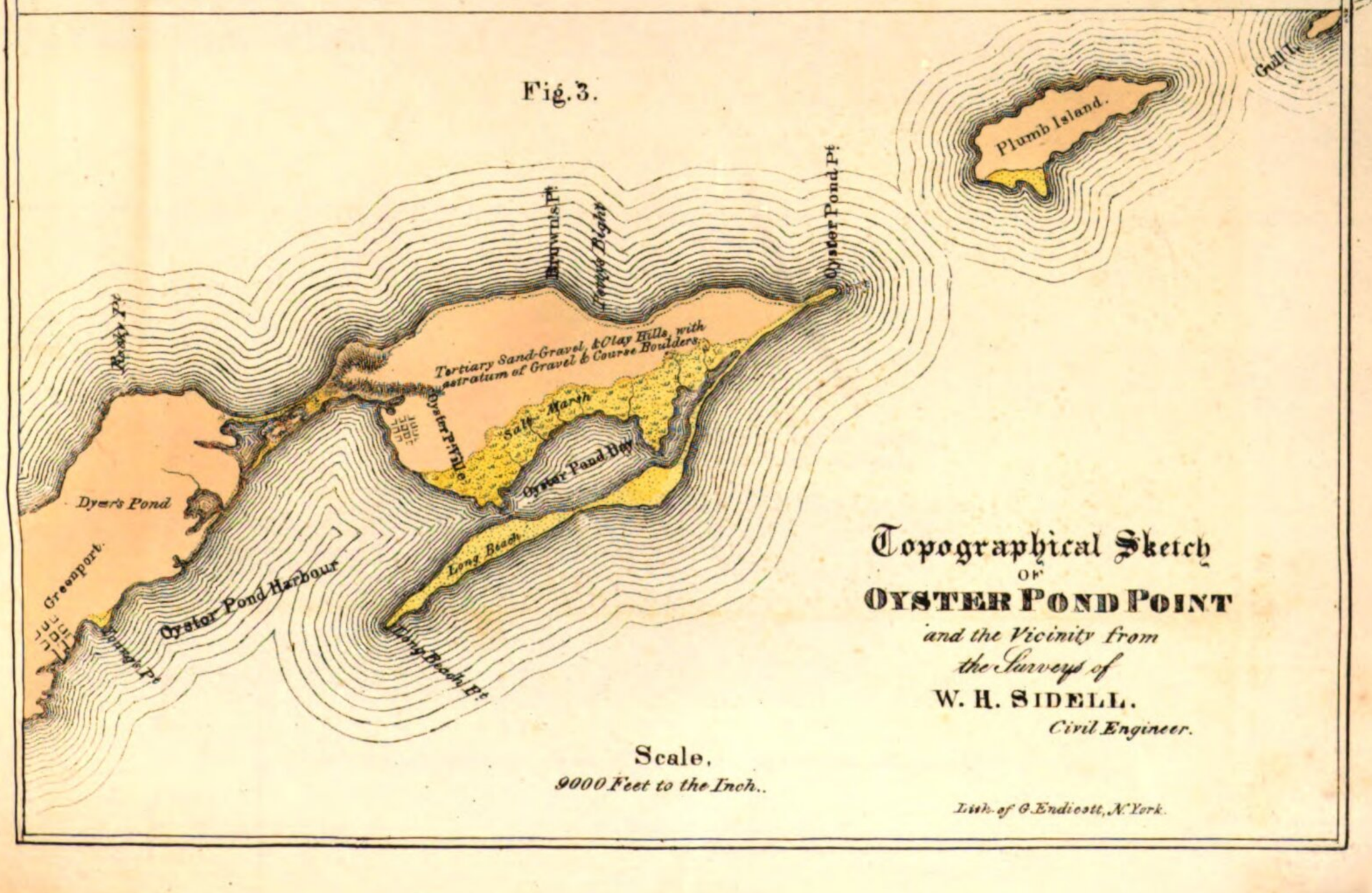


Fig. 3.



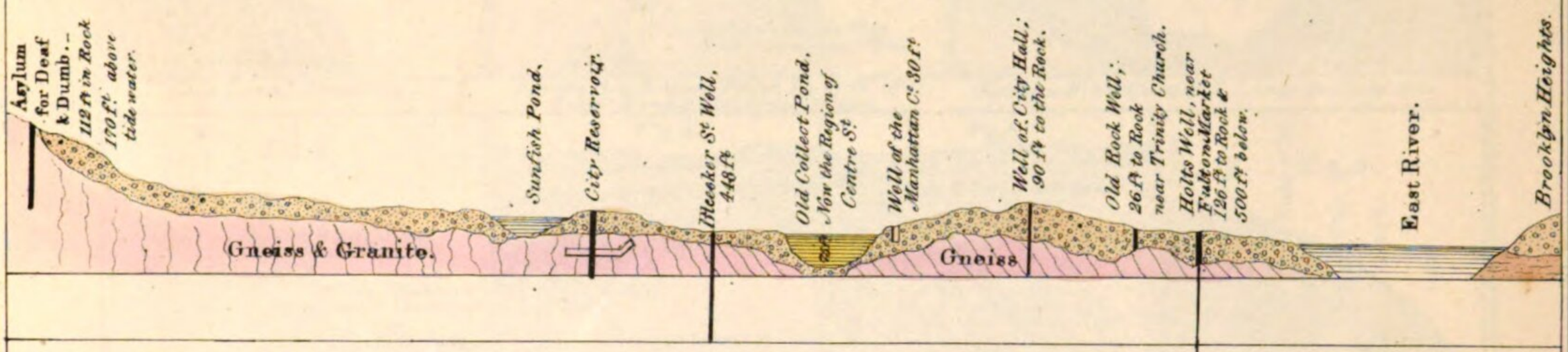
Scale.
9000 Feet to the Inch..

Topographical Sketch
OF
OYSTER POND POINT
and the Vicinity from the Surveys of
W. H. SIDELL.
Civil Engineer.

Lith. of G. Endicott, N. York.

Fig. 1.

Geological Section, *on the Island of New-York parallel to the strike of the strata from near 50th Street on the North to Brooklyn Heights on the South shewing the depths of earth and rock perforated in boring wells.*



Section *perpendicular to the strike; across the Island of New-York, shewing the depth to the rock.*

Fig. 2.

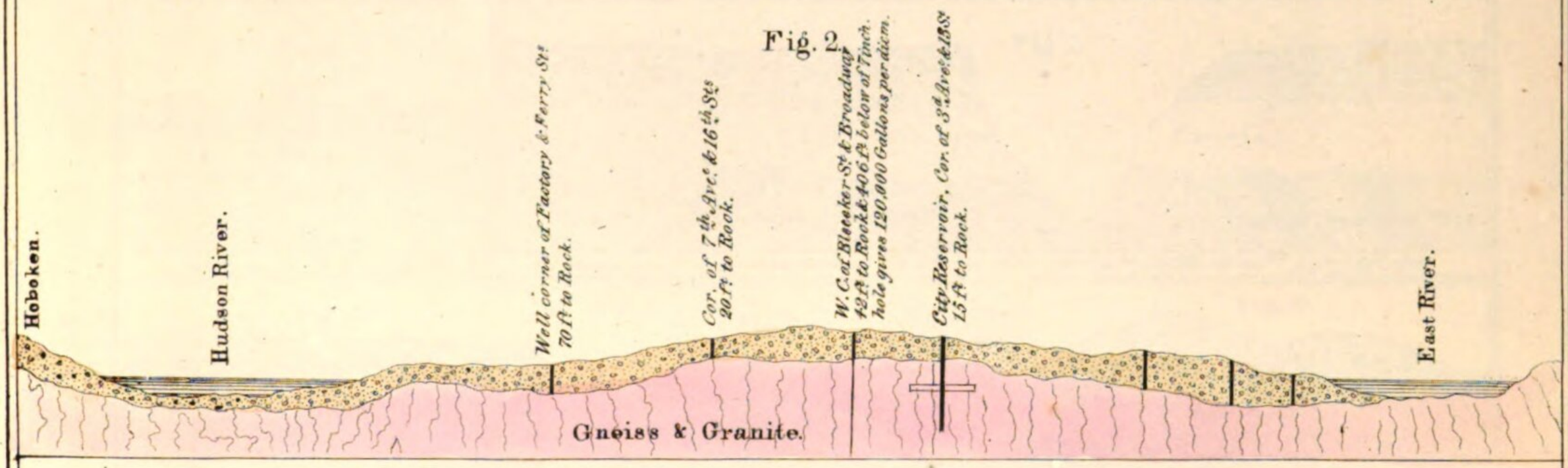
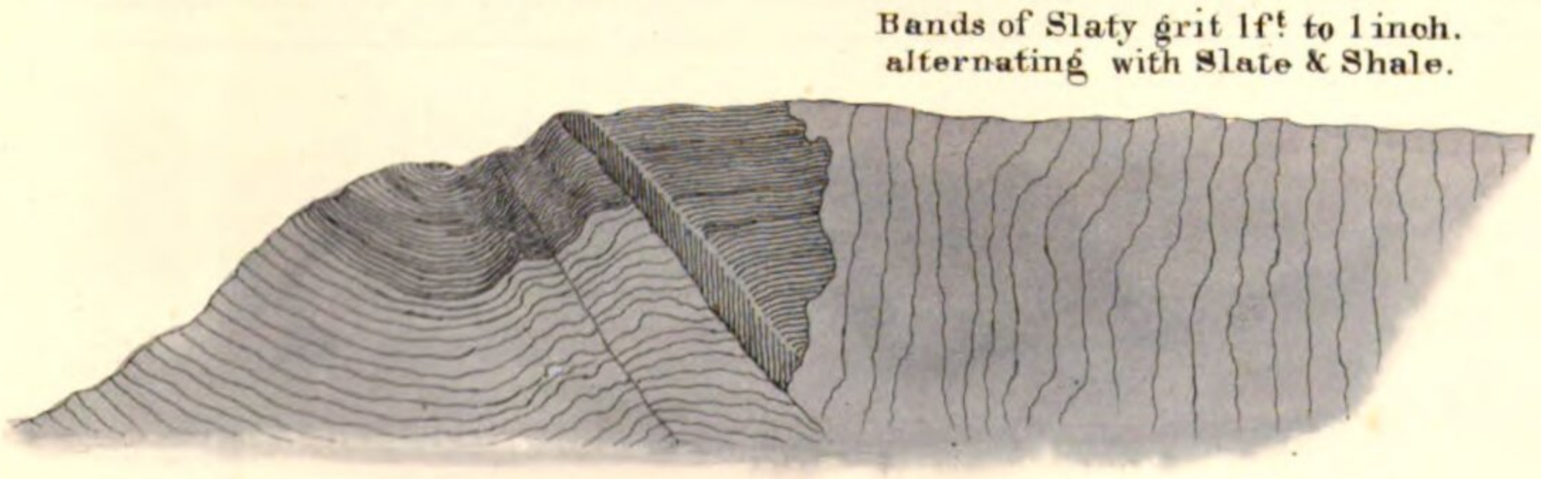


Fig. 3.

Hudson Slate-rocks.



J. Wickmin's quarry, ½ m. E. of Lansingburgh, Rensselaer Co. N. Y.

Lith. of O. Endicott, N.Y.

Sections of Long Island.

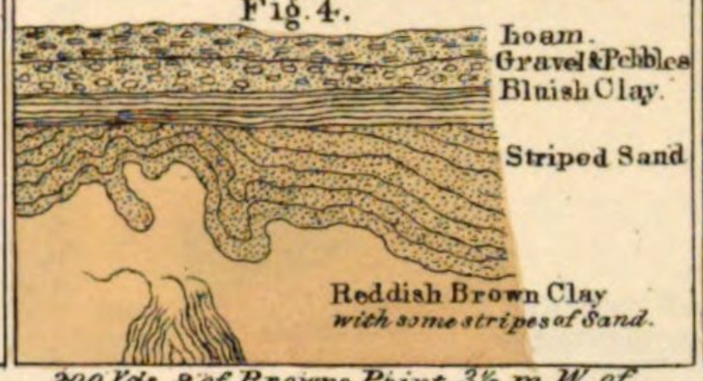
PLATE 4.

Fig. 1.



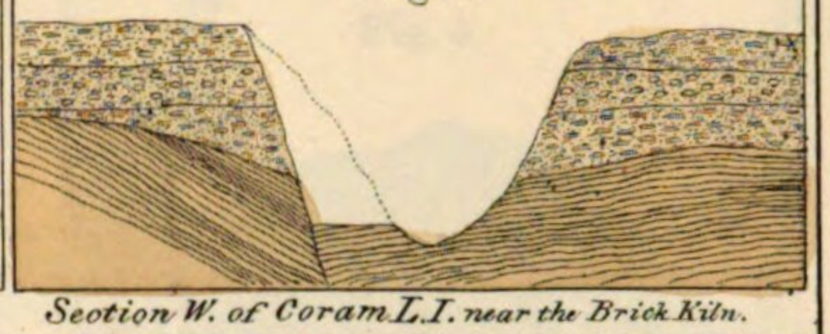
Long Island formation.

Fig. 4.



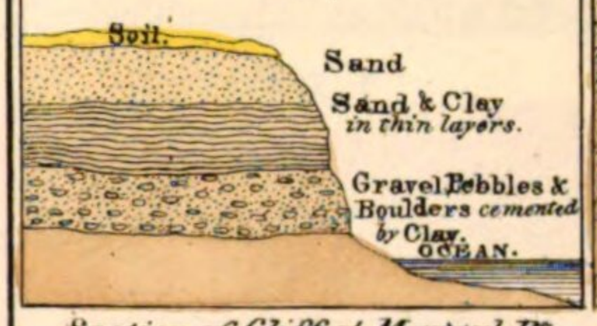
200 Yds. S. of Browns Point, 3½ m. W. of Oyster Pond Point, Long Island.

Fig. 11.



Section W. of Coram L.I. near the Brick Kiln.

Fig. 2.



Section of Cliff at Montauk Pt

Fig. 5.



Sections, exposed by encroachments of the Sea near Browns Pt Petty's Bight, Long Island.

Fig. 6.

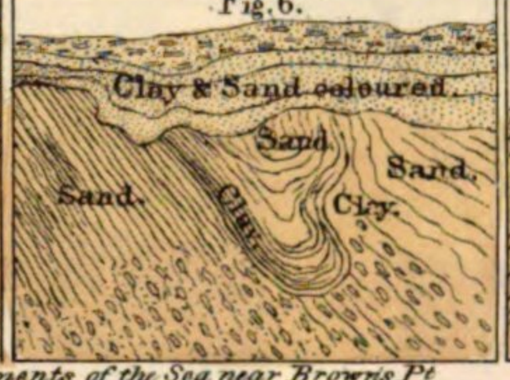
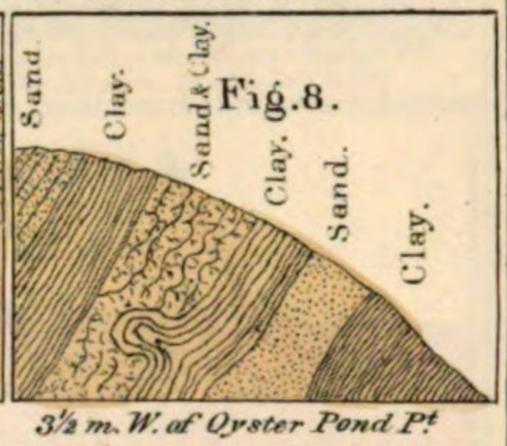
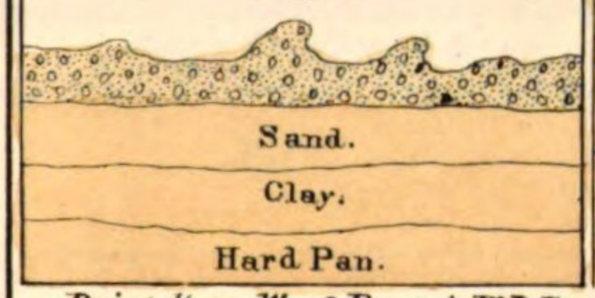


Fig. 8.



3½ m. W. of Oyster Pond Pt

Fig 3.



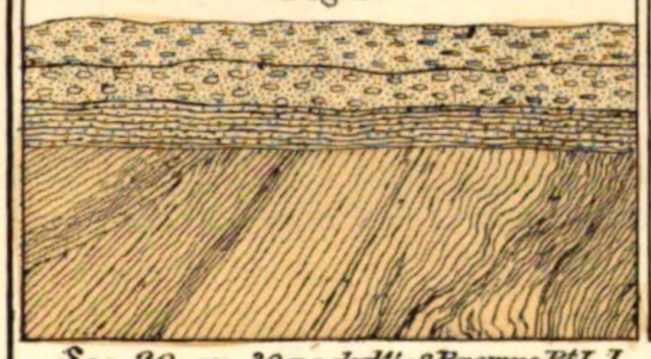
Point ½ m. W. of Brown's Pt L.I.

Fig. 7.



Section exposed after the Storm of 11 & 12th Oct. 1836, 200 yards S. of Brown's Pt. Long Island.

Fig. 15.



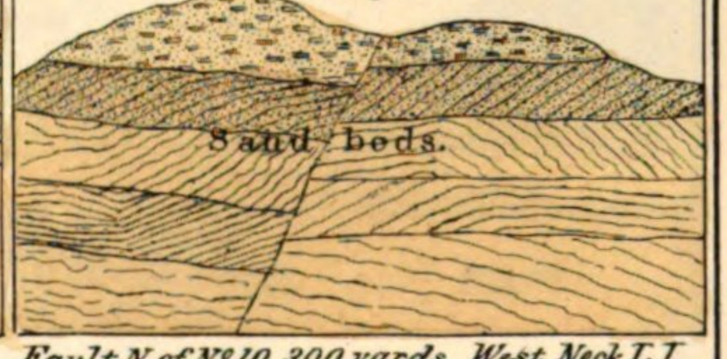
Sec. 20, on 30 rods W. of Browns Pt L.I.

Fig. 9.



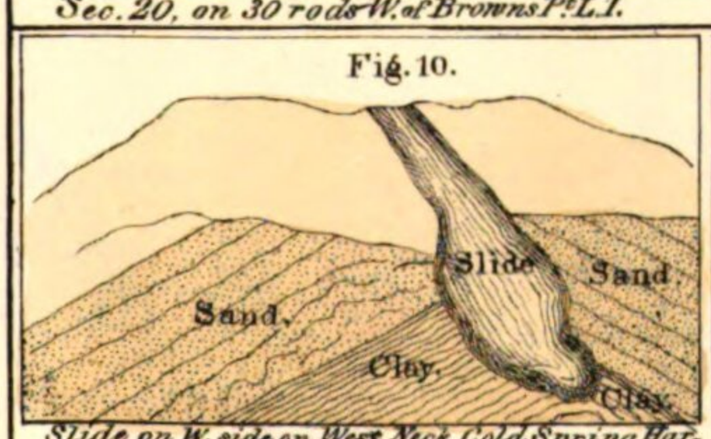
Land Slide 1½ m. W. of Browns Pt L.I.

Fig. 12.



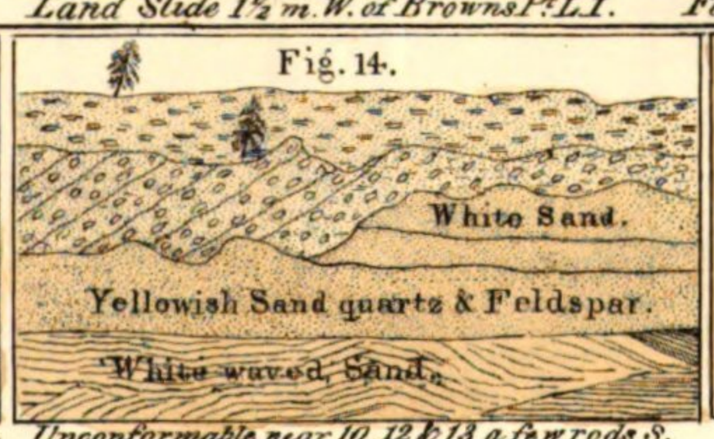
Fault N. of No 10 300 yards. West Neck L.I.

Fig. 10.



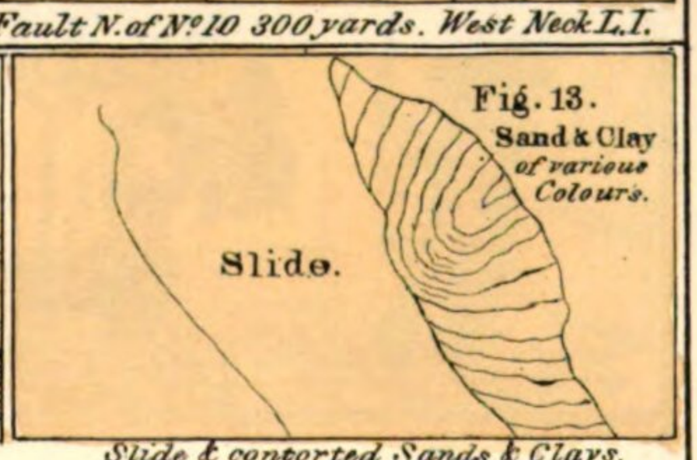
Slide on W. side on West Neck Cold Spring Harbour Long Island.

Fig. 14.



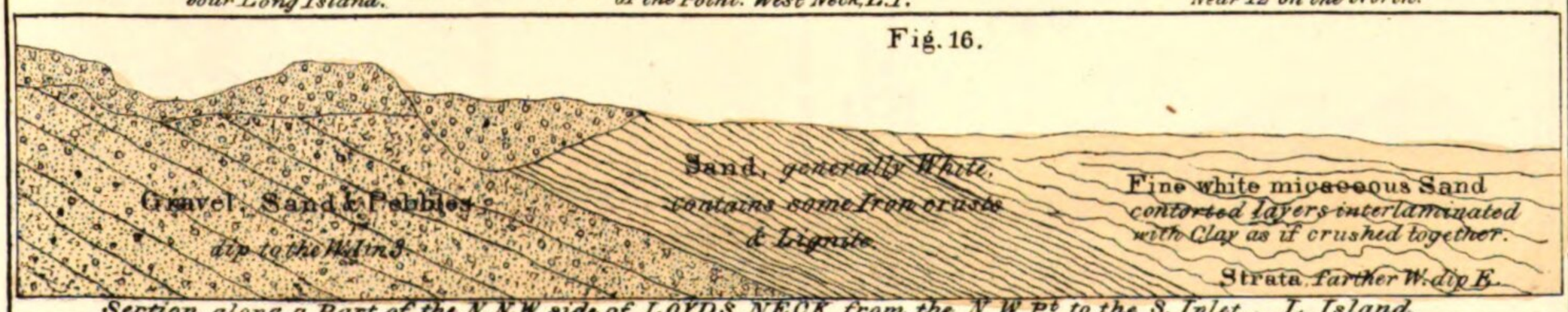
Unconformable near 10, 12 & 13 a few rods S. of the Point. West Neck, L.I.

Fig. 13.



Slide & contorted Sands & Clays. Near 12 on the North.

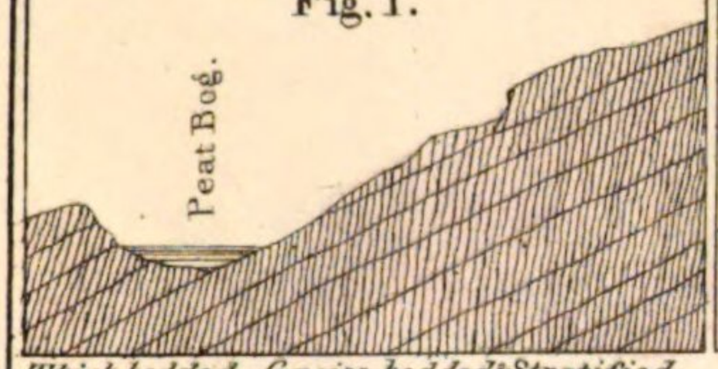
Fig. 16.



Section along a Part of the N.N.W. side of LOYD'S NECK from the N.W. Pt to the S. Inlet. L. Island.

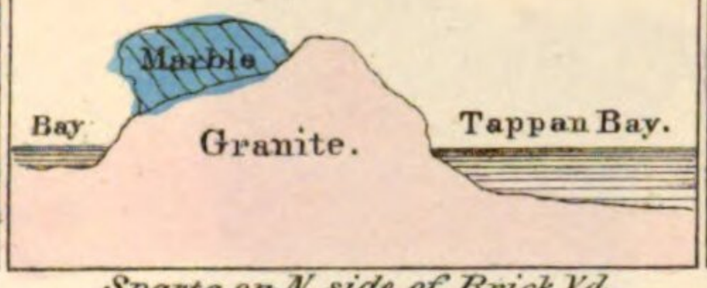
Lith. of G. Endicott, N. York.

Fig. 1.



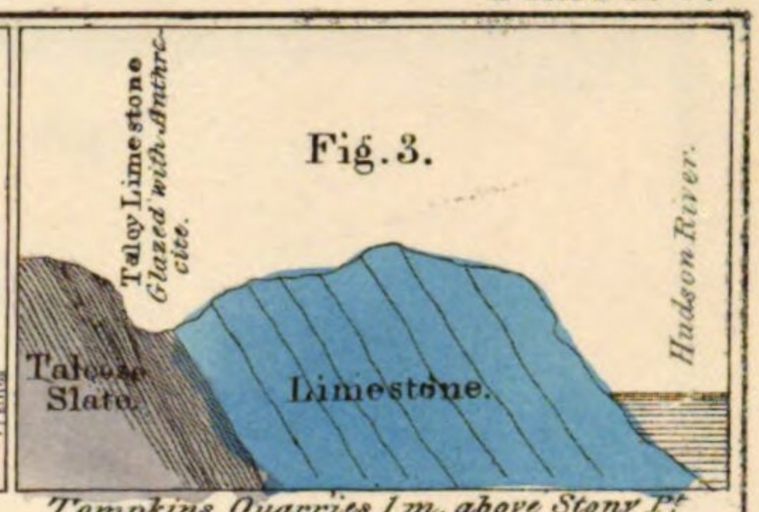
Thick bedded Gneiss bedded & Stratified, Phillips Quarry 1½ m. E.N.E. of W. Point.

Fig. 2.



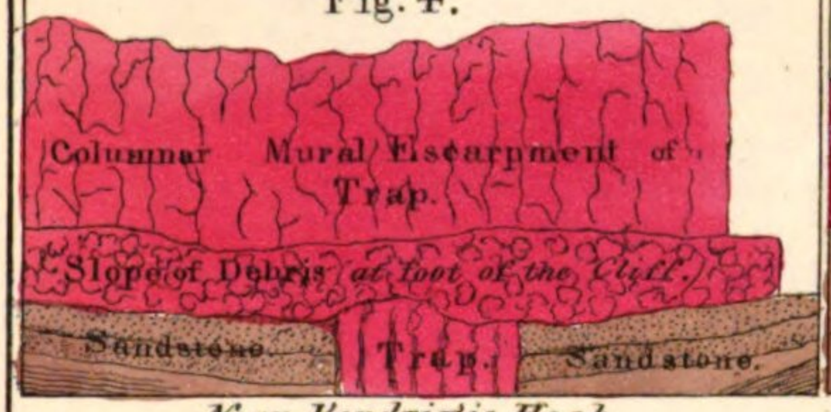
Sparta on N. side of Brick Yd. 1 or 1½ m. S. of Mt. Pleasant.

Fig. 3.



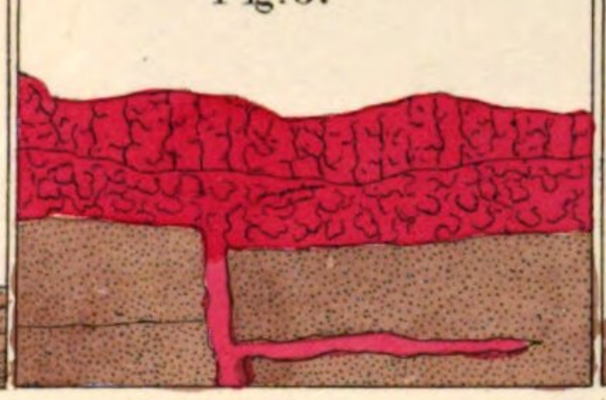
Tompkins Quarries 1 m. above Stony Pt on Shore of the Hudson. Rockland Co. N.Y.

Fig. 4.



Near Verdrietje Hook. Enormous dyke or double fault.

Fig. 5.



1½ or 2 m. S. of Haverstraw.

Fig. 6.



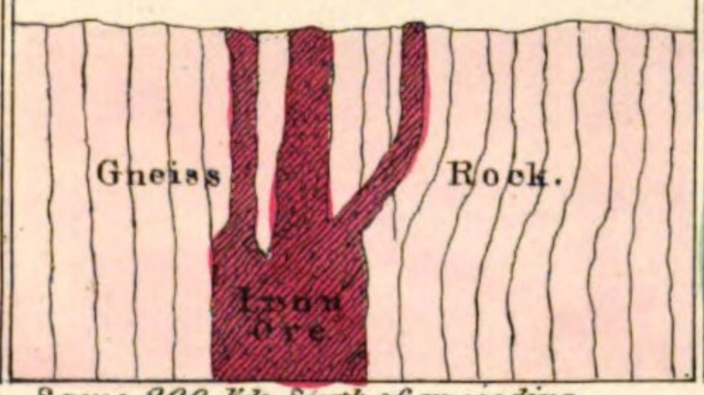
Trap escarpment & talus of Debris.

Fig. 7.



Denney Ore Bed. Mag-Ox Iron. Phillipstown Putnam Co. N.Y.

Fig. 8.



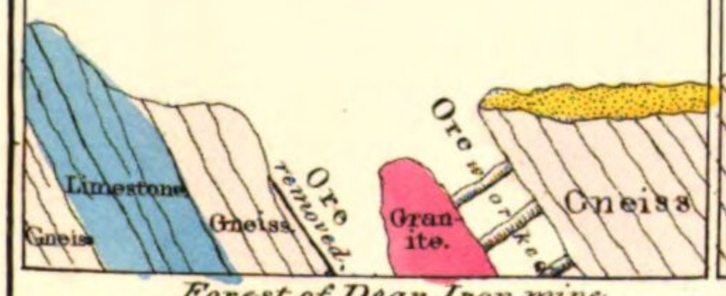
Same 200 Yds. South of preceding. Phillipstown, Putnam Co. N.Y.

Fig. 14.



Townsend's Ore-bed, Orange Co. N.Y.

Fig. 9.



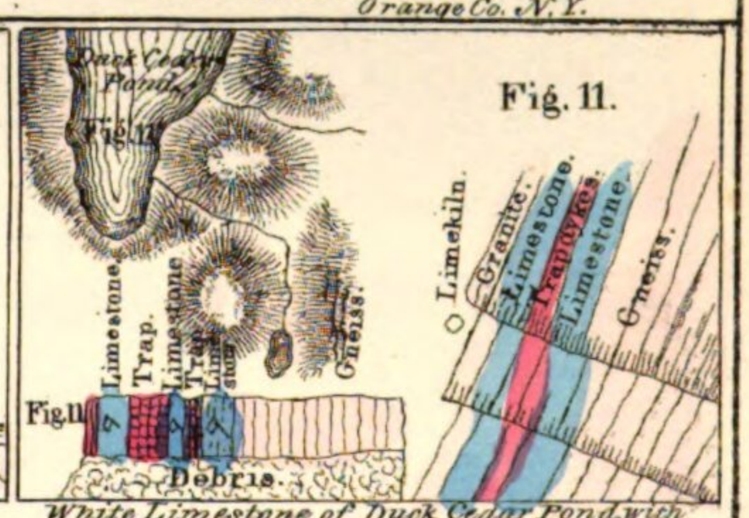
Forest of Dean Iron mine. Cornwall, Orange Co. N.Y.

Fig. 10.



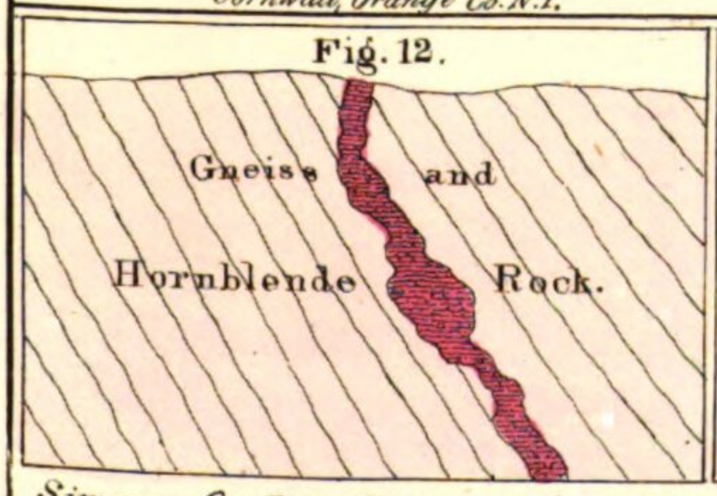
Patterson Mine, Mt. mine & Crossway mine. Mag Ox Iron. Monroe Orange Co. N.Y.

Fig. 11.



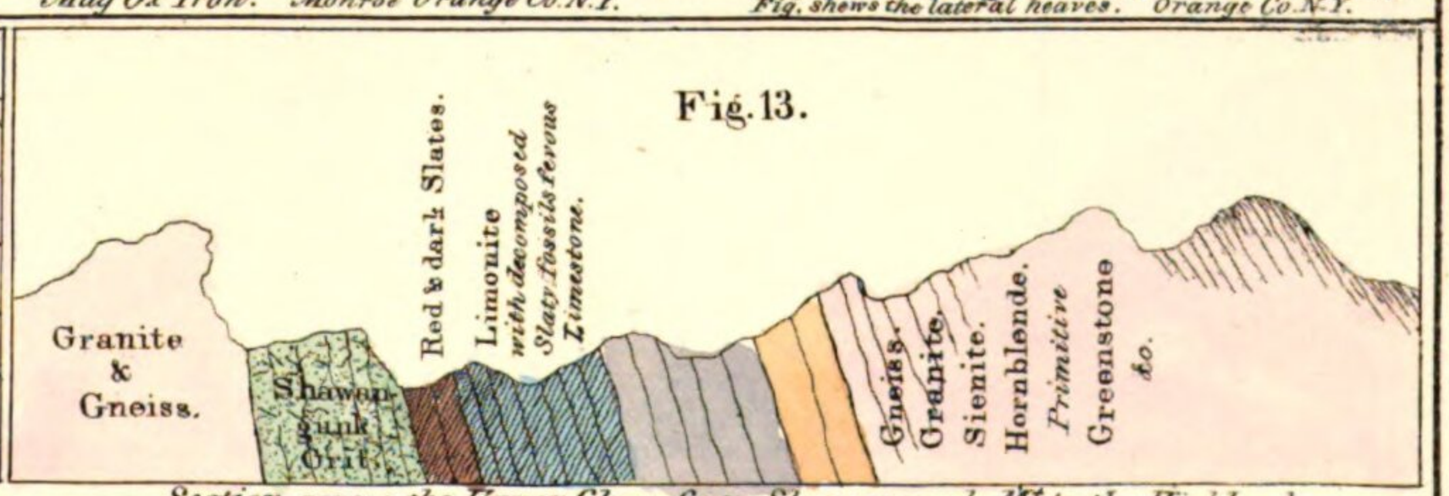
White Limestone of Duck Cedar Pond, with trapdykes & numerous crystallized Minerals. Side Fig. shews the lateral heaves. Orange Co. N.Y.

Fig. 12.



Simewog Ore-bed, Magnetic oxide of Iron.

Fig. 13.

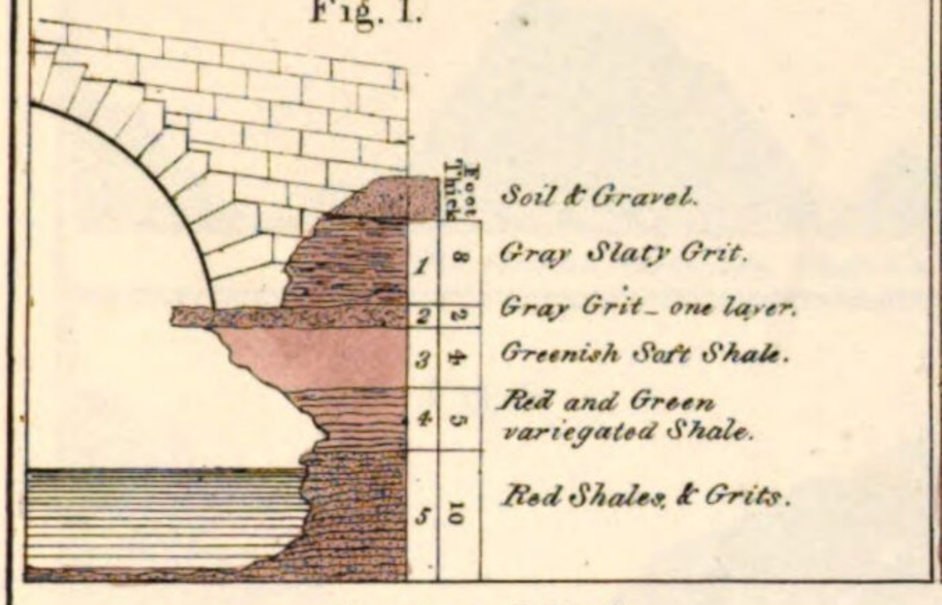


Section across the Upper Clove from Skunnemunk Mt. to the Highlands. Orange Co. N.Y.

Imman Seymour Jr. dele.

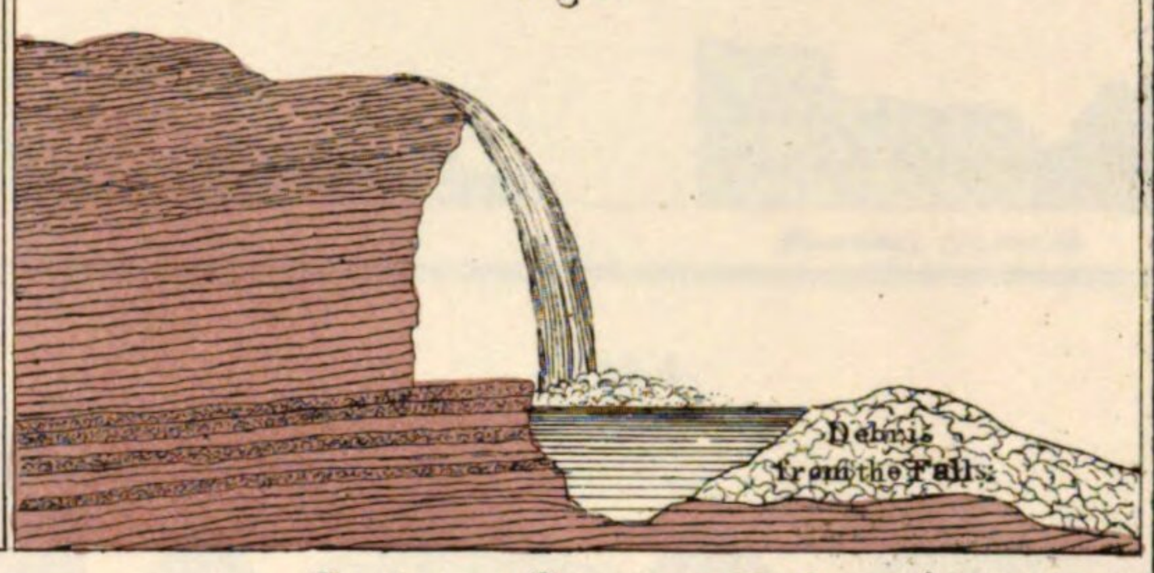
Lith. of G. Endicott N. York

Fig. 1.



Section of Rocks
at the Bridge on the Catskill & Ithica Turnpike 4 or 5 m. E. of Durham Greene Co. N.Y.

Fig. 2.



Section at Stratton's Falls
on Stratton's Falls Brook - Roxbury. Delaware Co. N.Y.

Fig. 3.



Fig. 4.



Examples *of the Water Lines of Deposition, so common in the Gray Grits of Ulster, Sullivan, Greene and Delaware Counties_ and which have sometimes been mistaken for lines of Stratification.*

Fig 5.

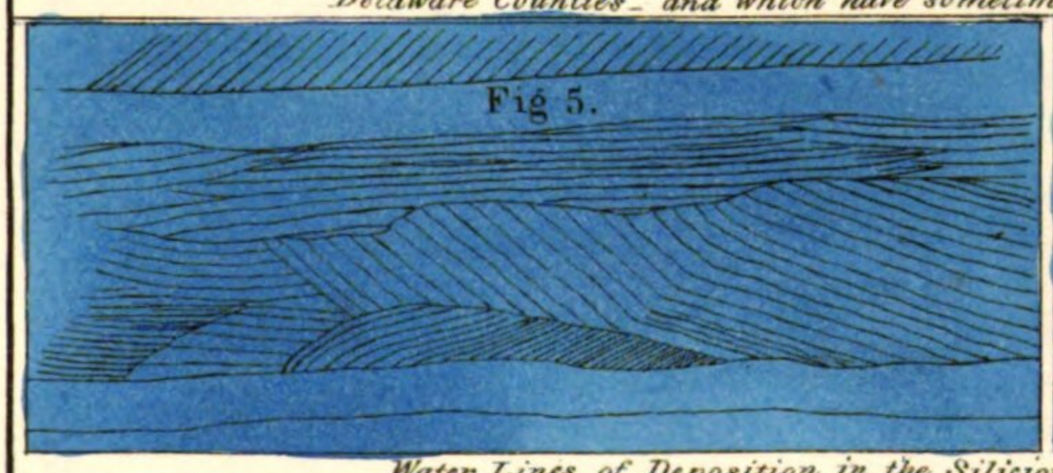
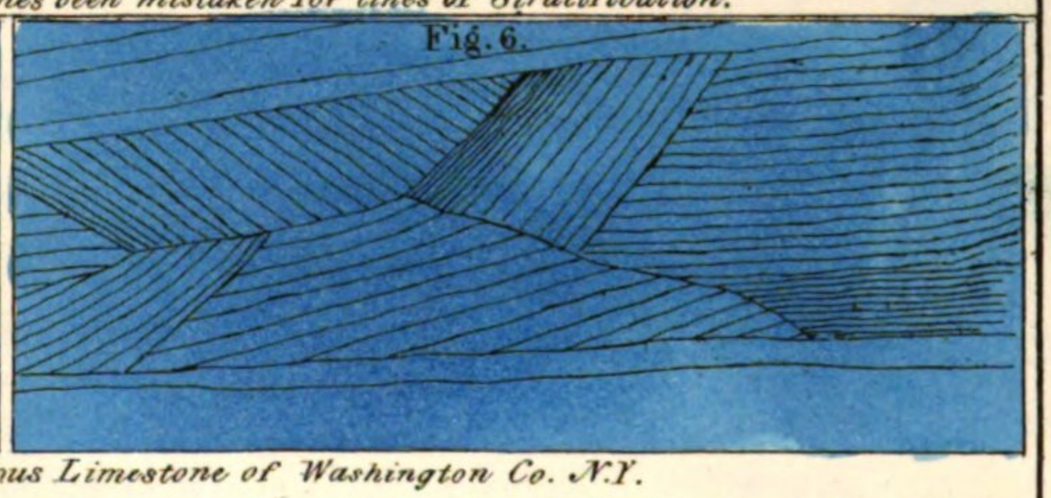
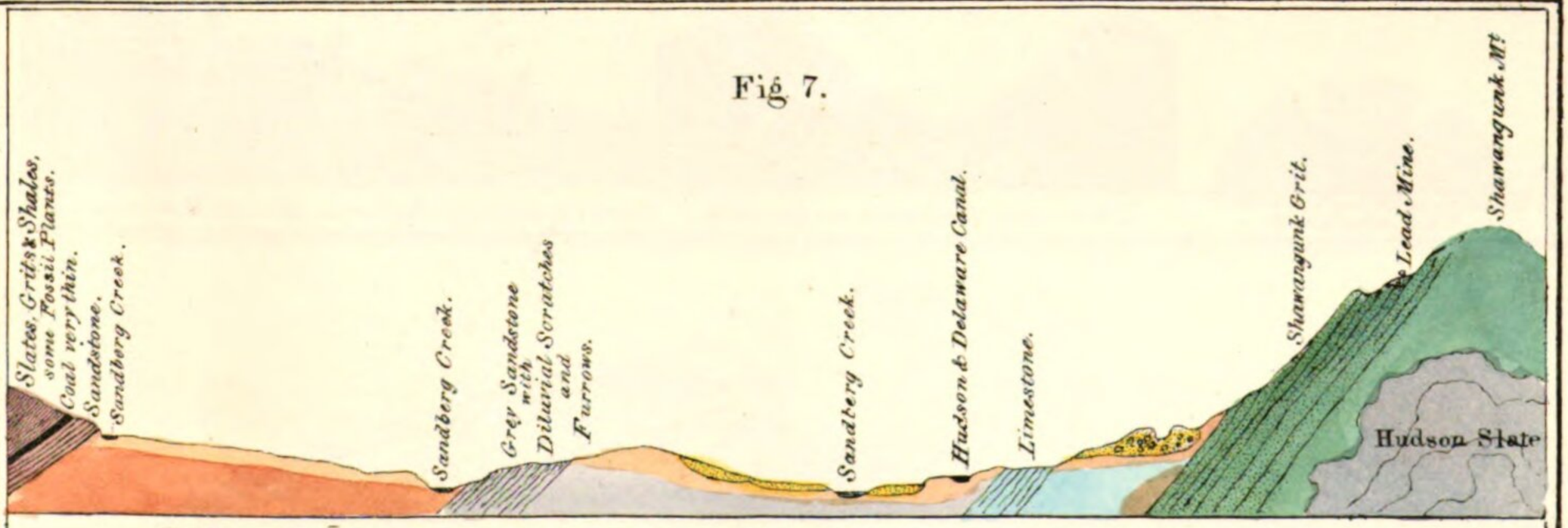


Fig. 6.



Water Lines of Deposition in the Silicious Limestone of Washington Co. N.Y.
(1 mile E. of Whitehall Washington Co.) *(5 mile E. of Fort Ann Washington Co.)*

Fig. 7.



Section *from the Shawangunk Mt. to the "Coal-mine" on the Sandberg Mt. near Red-Bridge: Sullivan Co.*

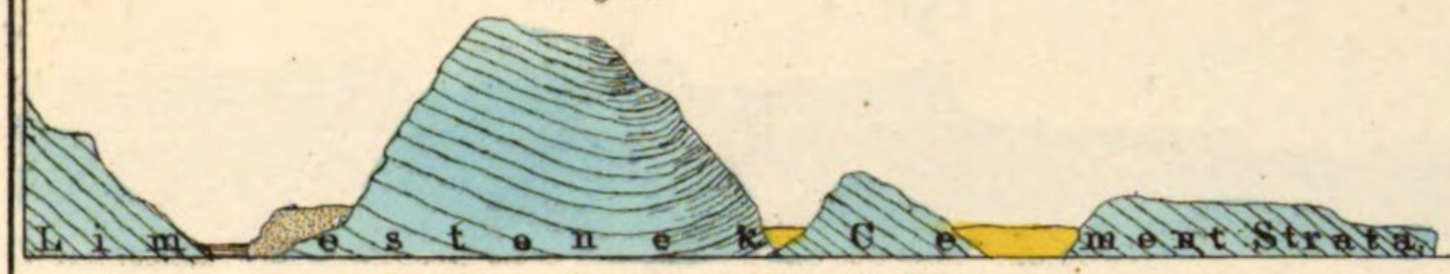
Lith. of G. Endicott. N.Y.

Sections.

Helderberg Shawangunk & Hudson Slate Rocks.

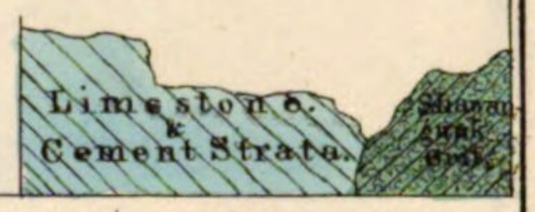
PLATE 7.

Fig. 1.



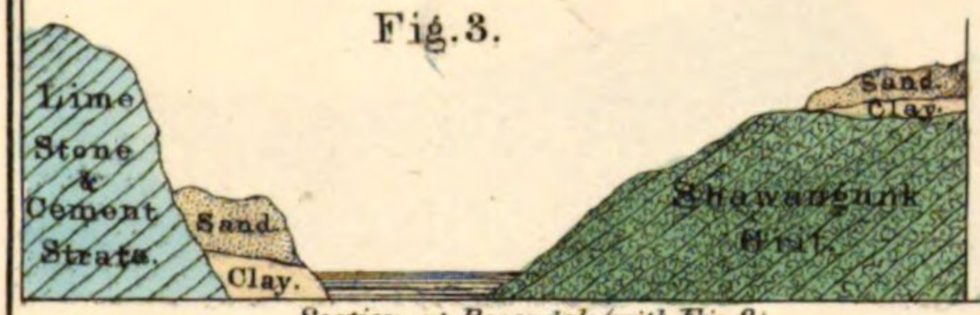
Section at Rosendale, Ulster Co. N.Y.

Fig. 2.



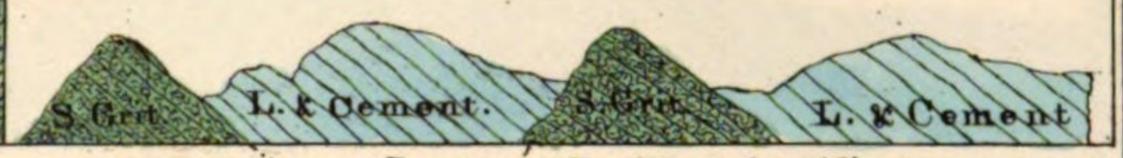
Rosendale Ulster Co.

Fig. 3.



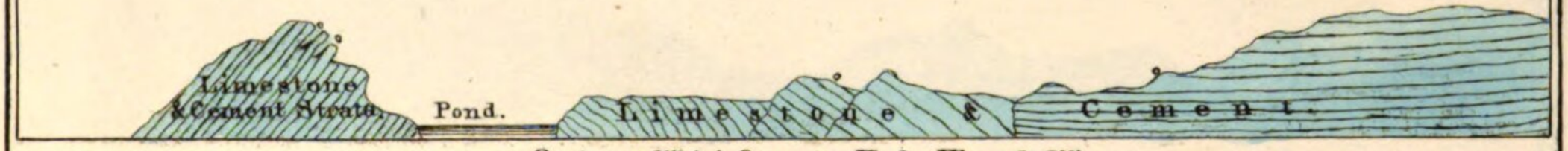
Section at Rosendale (with Fig 2) as they appear to the eye.

Fig. 4.



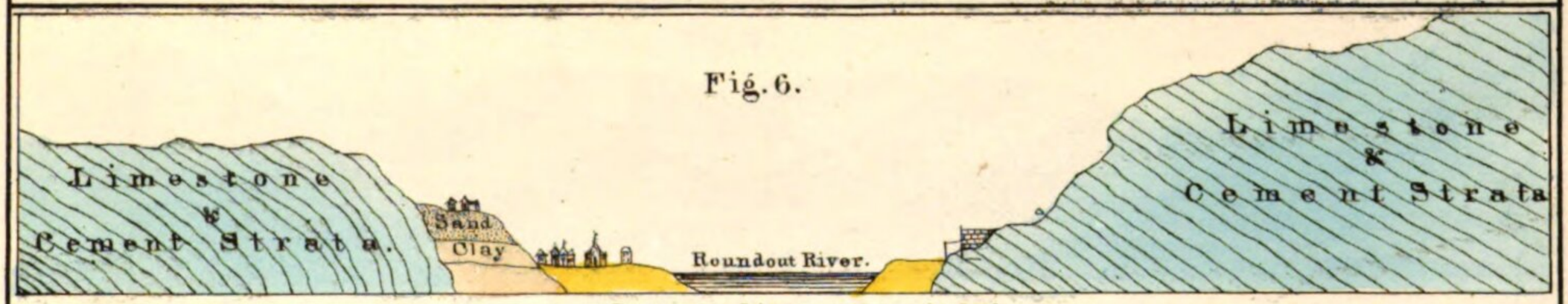
Section at Lawrenceville, Ulster Co. N.Y.

Fig. 5.



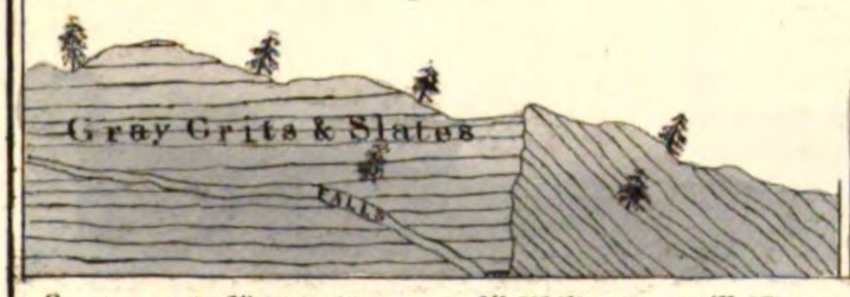
Section at White's Quarries. Hurley, Ulster Co. N.Y.

Fig. 6.



Section at Wilbur, Ulster Co. N.Y.

Fig. 7.



Section at the Wallkill Fall on the Wallkill at Dashville Ulster Co.

Fig. 8.



Arched Strata at Dashville, Ulster Co. N.Y.

Fig. 8.



Cracks in Fig 8. filled with Calc Spar, Dashville N.Y.

Fig. 9.



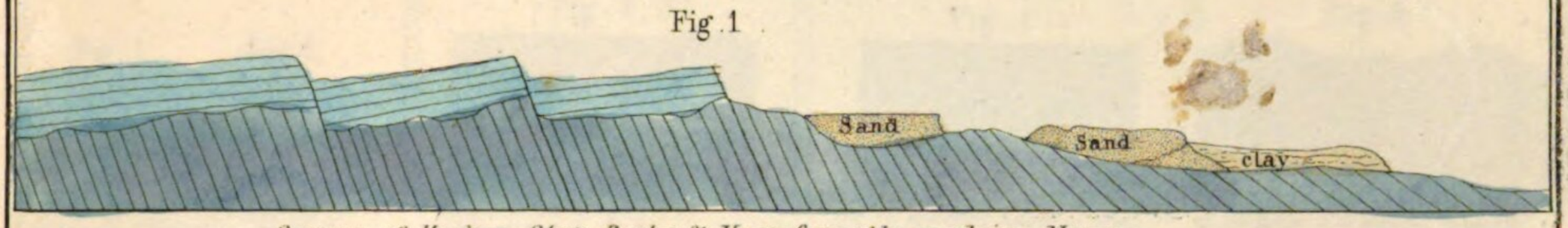
Section between Glasco & the Great Falls of Esopus Creek N.Y.

T. Seymour, Jr. Lo.

Lith. of G. Endicott N. York

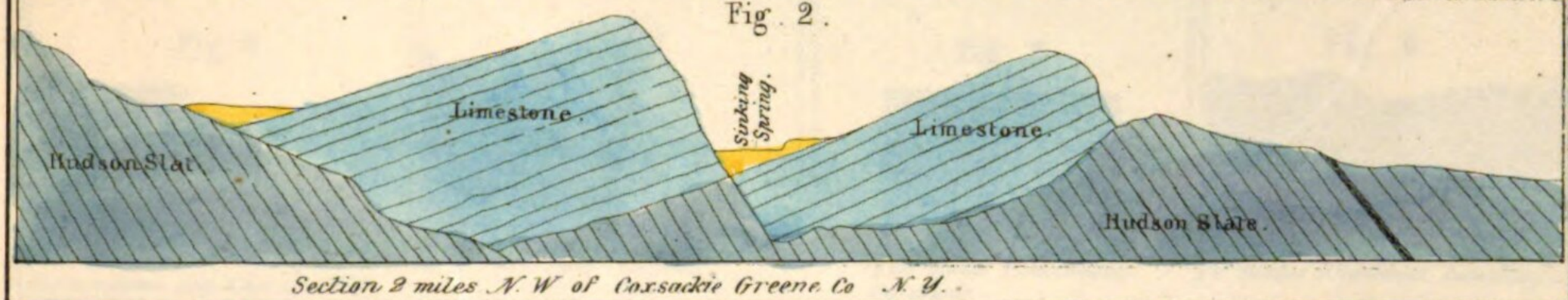
PLATE 8.

Fig. 1



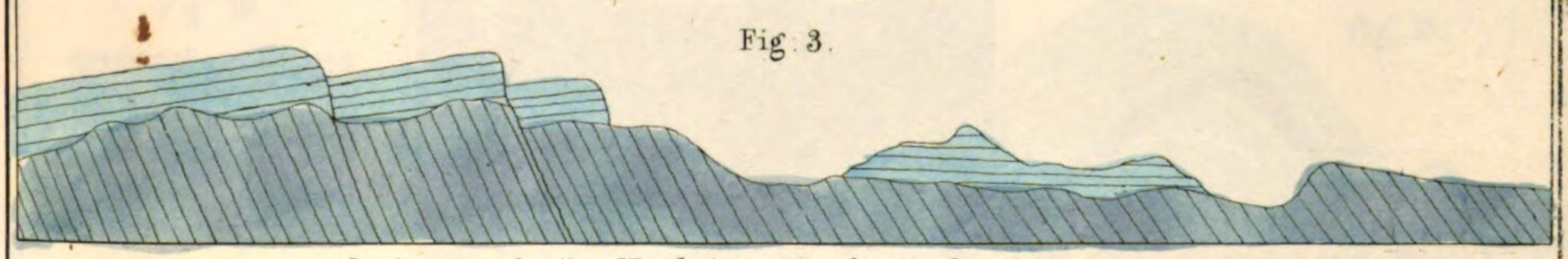
Section of Hudson Slate Rocks & Unconformable overlying Masses.

Fig. 2.



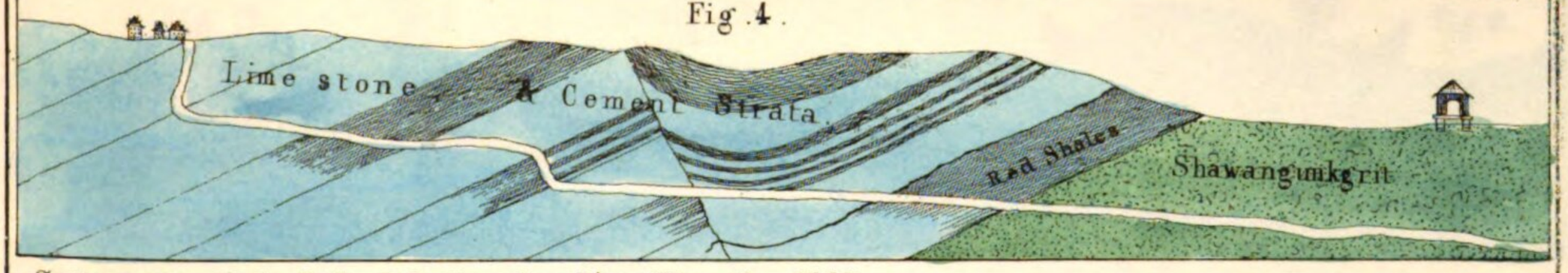
Section 2 miles N. W of Coxsackie Greene Co N. Y.

Fig. 3.



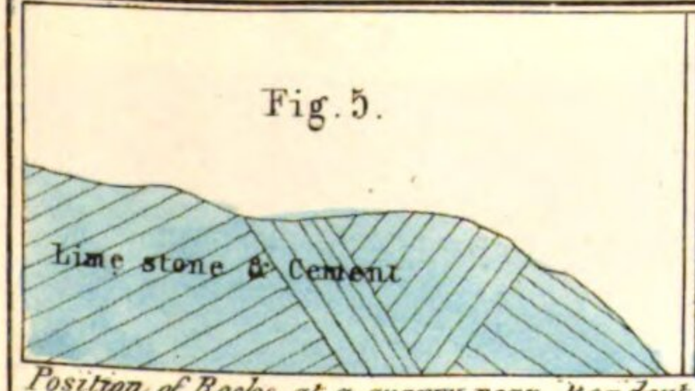
Section 2 or 3 miles W. of Coxsackie Greene Co. N. Y.

Fig. 4.



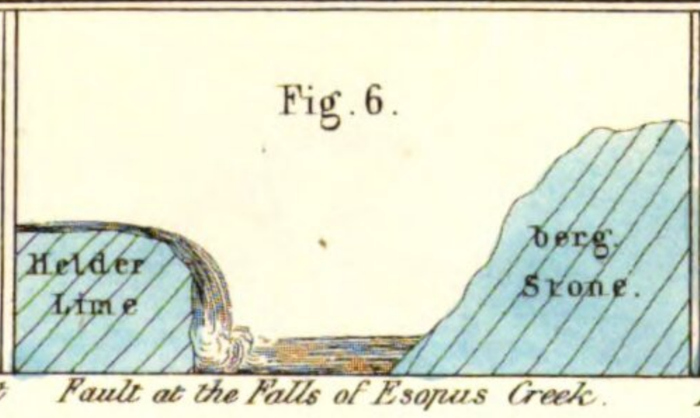
Section at the High Falls of the Rondout River Ulster Co. N. Y.

Fig. 5.



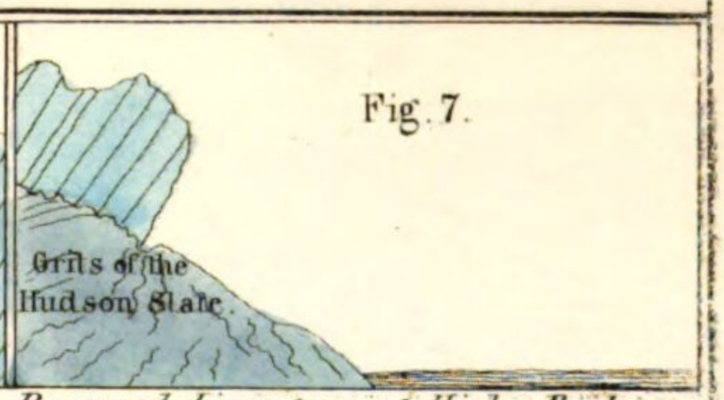
Position of Rocks at a quarry near Rondout Ulster Co N. Y.

Fig. 6.



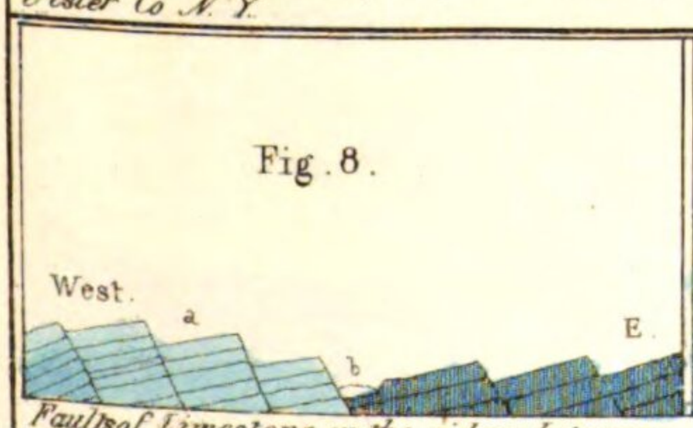
Fault at the Falls of Esopus Creek.

Fig. 7.



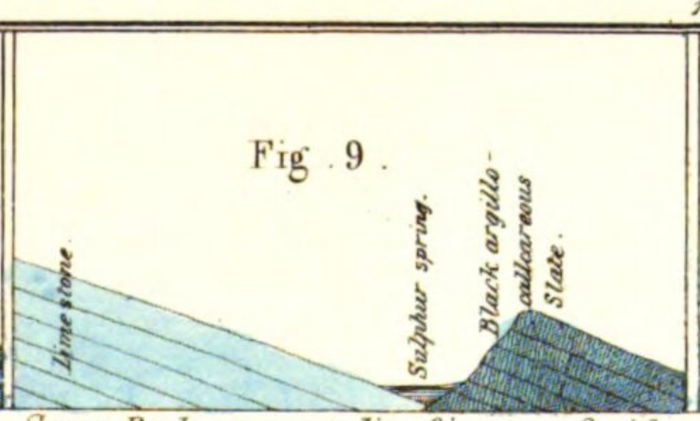
Reversed Limestone at High Rocks 1 m. N.W. of Kingston Pt. Ulster Co N. Y.

Fig. 8.



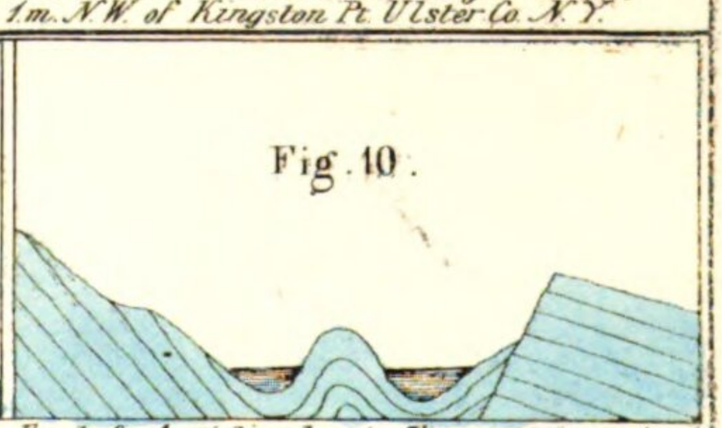
Faults of Limestone on the ridges between Kingston & Hurley Ulster Co N. Y.

Fig. 9.



Same Rocks as preceding figure on S. side of the Antidinal axis

Fig. 10.



Fault & Anticlinal axis. Transverse section across the N end of Lake Marbletown Ulster Co N. Y.

T. Seymour Jr. ft.

Lith of Endicott N. Y

Contortions & Faults.

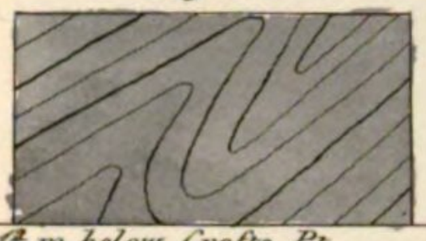
PLATE 9.

Fig. 1.

Fig. 2.

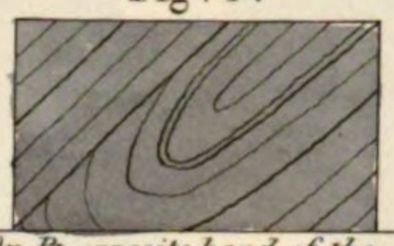
Slate rocks at Pt. 1½ m. below Crofts Pt. Columbia Co. N.Y.

Fig. 3.



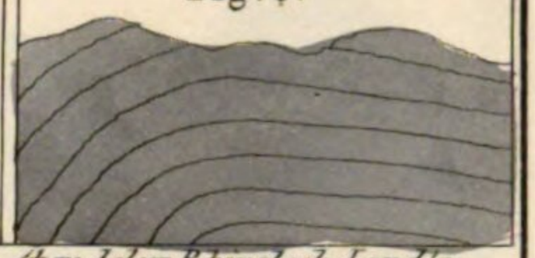
1½ m. below Crofts Pt. Columbia Co. N.Y.

Fig. 4.



On Pt. opposite head of the Island 2 or 3 m. below Crofts Pt.

Fig. 5.



1¼ m. below Rhinebeck Land'g.

Fig. 6.



Contortion opposite the Light House on E. shore below Bristol, Germantown Columbia Co. N.Y.

Fig. 7.



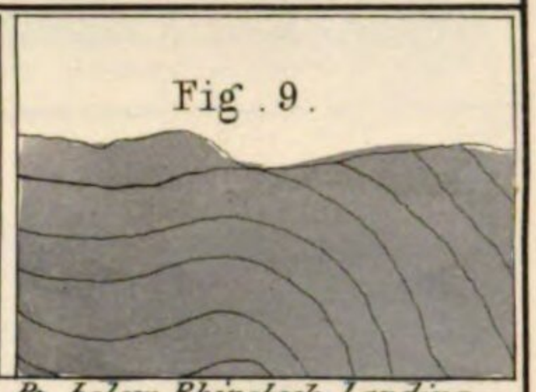
E. shore below Bristol.

Fig. 8.



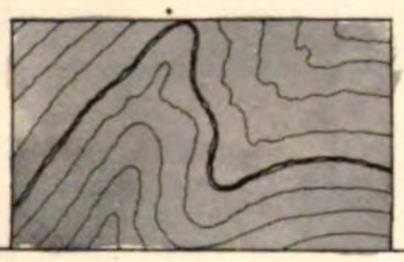
½ m. below Rhinebeck Landing.

Fig. 9.



Pt. below Rhinebeck Landing.

Fig 10.



Right bank of the Rondout Kill at Eddyville Ulster Co. N.Y.

Fig. 11.

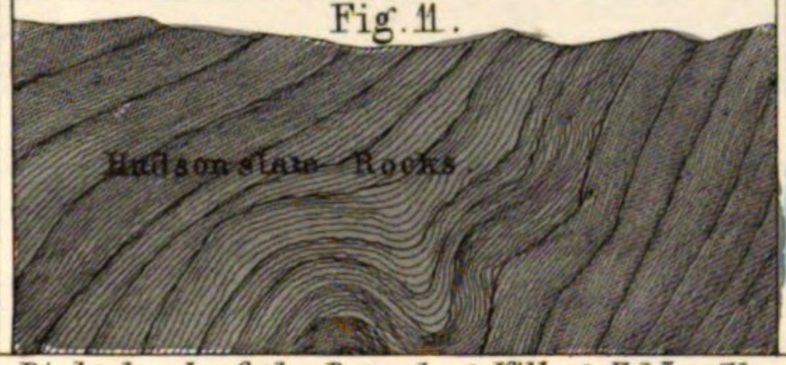
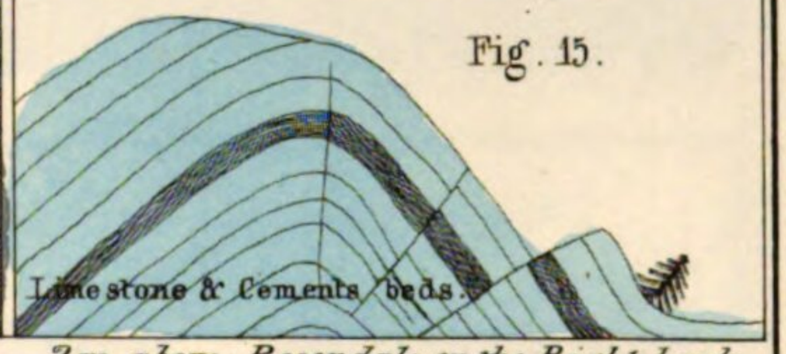
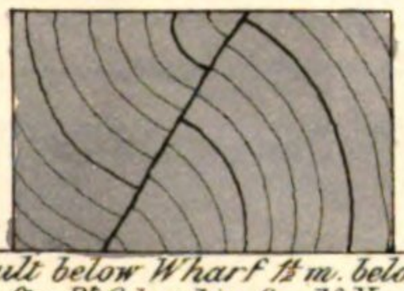


Fig. 15.



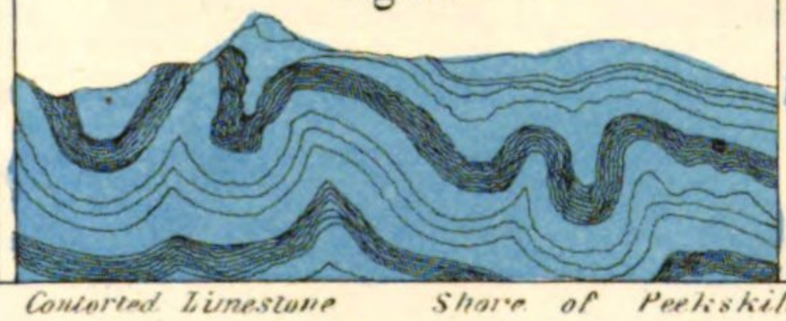
2 m. above Rosendale on the Right bank of the Rondout Ulster Co. N.Y.

Fig. 12.



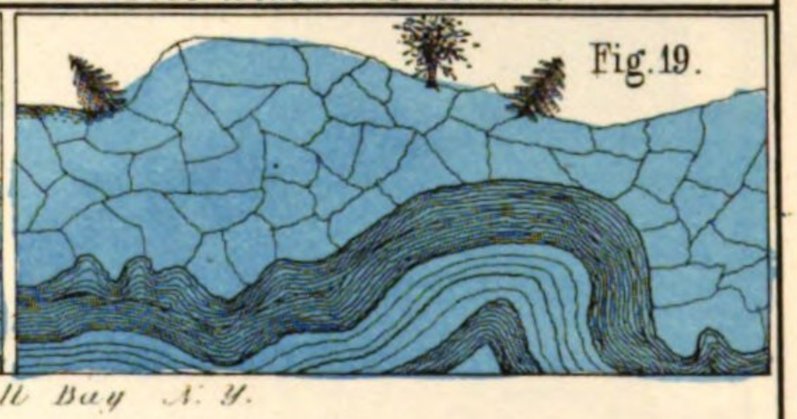
Fault below Wharf ½ m. below Crafts Pt Columbia Co. N.Y.

Fig. 16.



Contorted Limestone

Fig. 19.



Shore of Peekskill Bay N.Y.

Fig. 13.

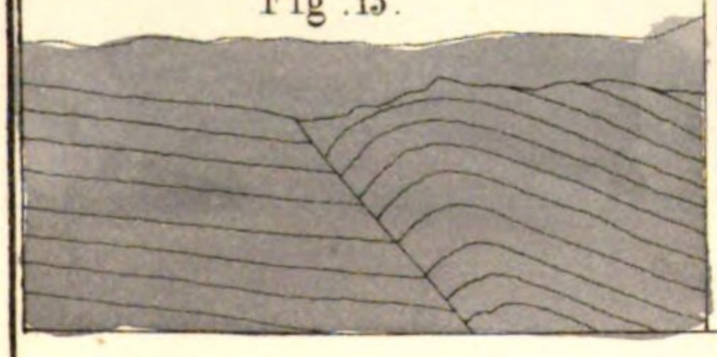


Fig. 17.

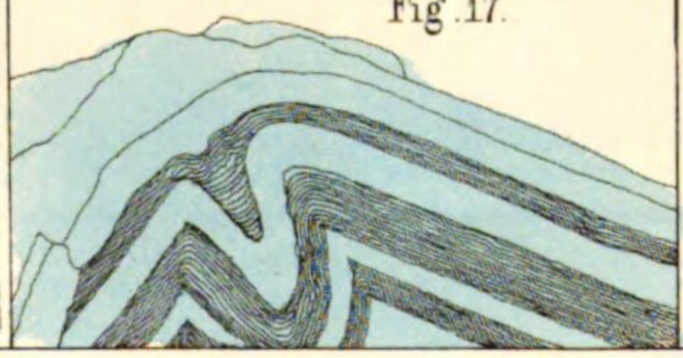


Fig. 18.

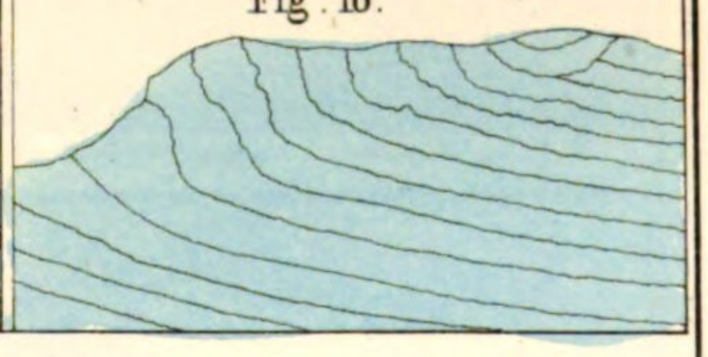


Fig. 14.

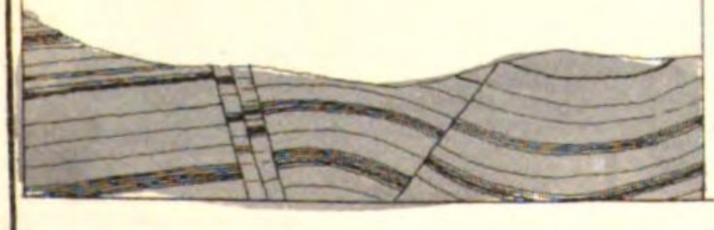


Fig. 20.

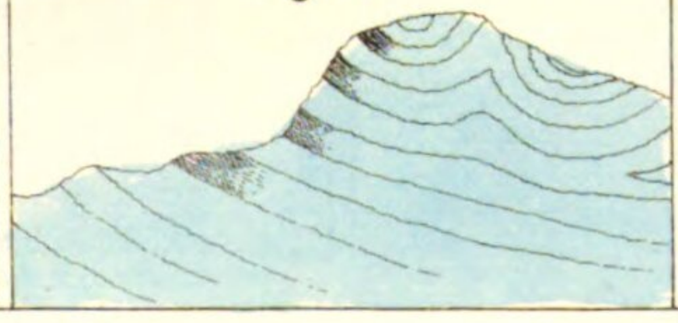
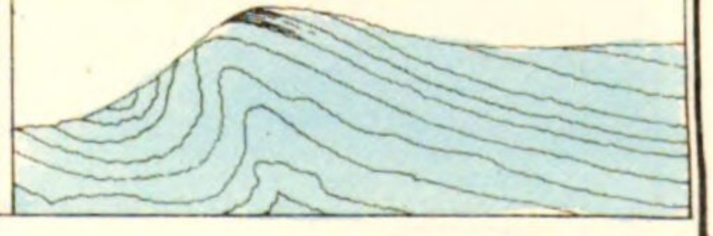


Fig. 21.

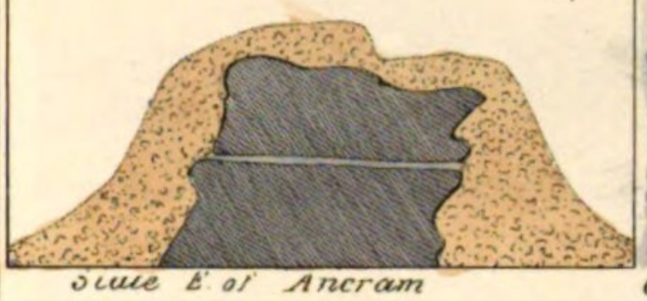


T. Seymour Jr fc.

Lith. of Endicott N.Y.

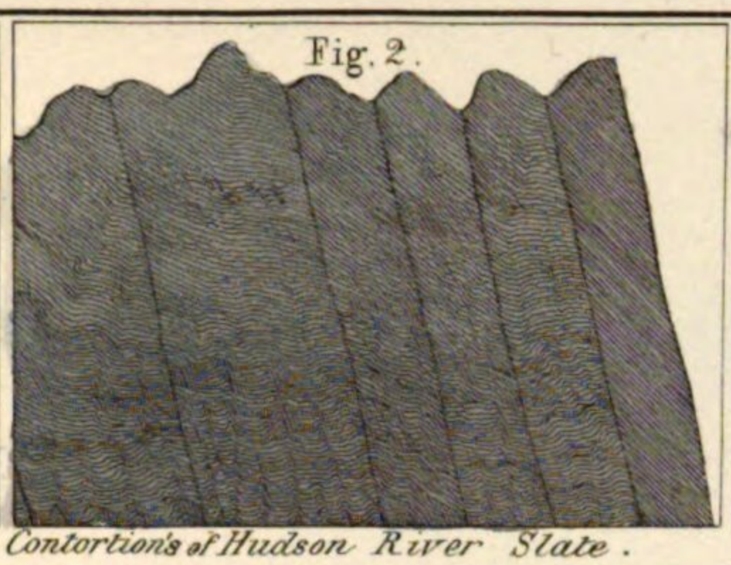
PLATE 10.

Fig. 1.



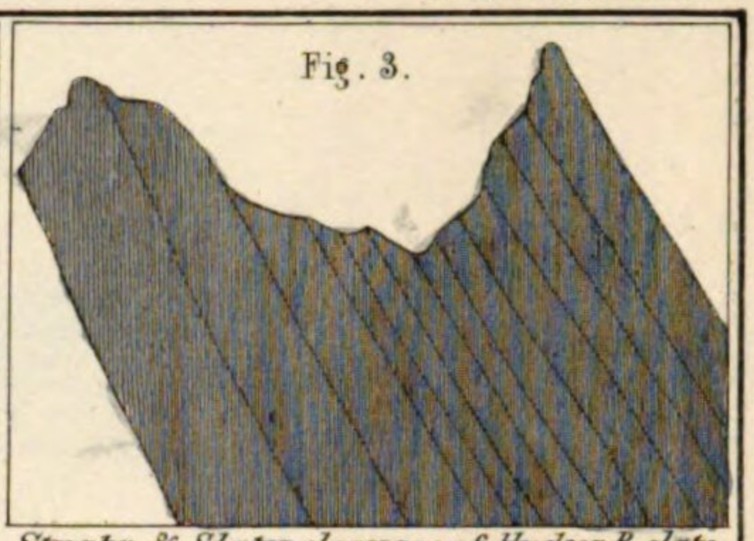
Slate E. of Ancram

Fig. 2.



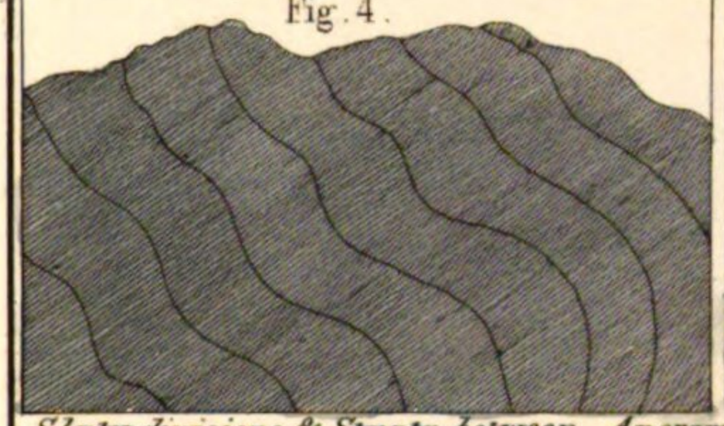
Contortions of Hudson River Slate.

Fig. 3.



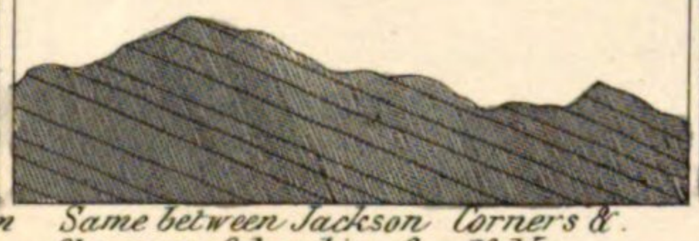
Strata & Slaty cleavage of Hudson R. slate.

Fig. 4.



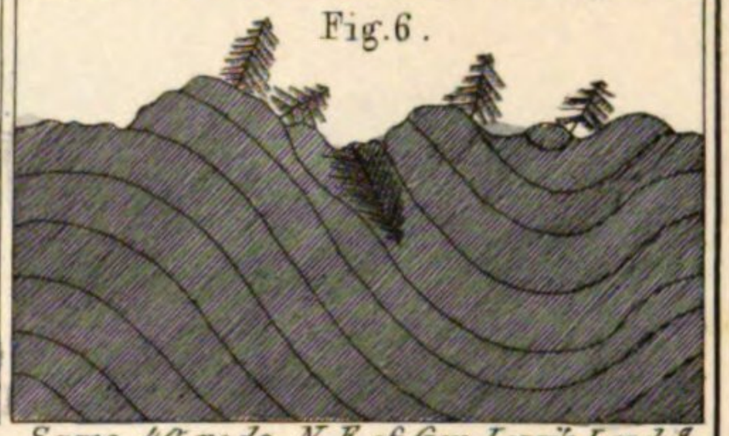
Slaty divisions & Strata between Ancram Iron Works & Lead mine Columbia County N.Y.

Fig. 5.



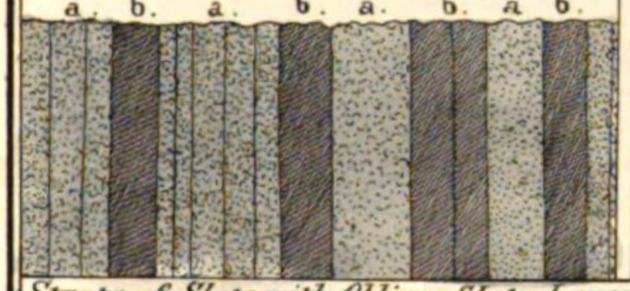
Same between Jackson Corners & Clermont, Columbia Co. N. Y.

Fig. 6.



Same 40 rods N.E. of Gen Lewi's Land's. Columbia Co. N. Y.

Fig. 7.

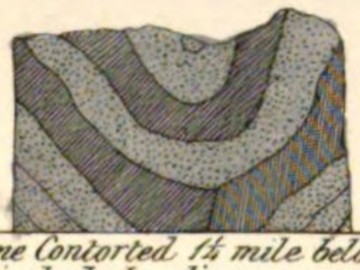


Strata of Slate with Oblique Slaty Layers interstratified with grit rocks 1m. below Rhinebeck Landing.

Fig. 8.



Fig. 9.



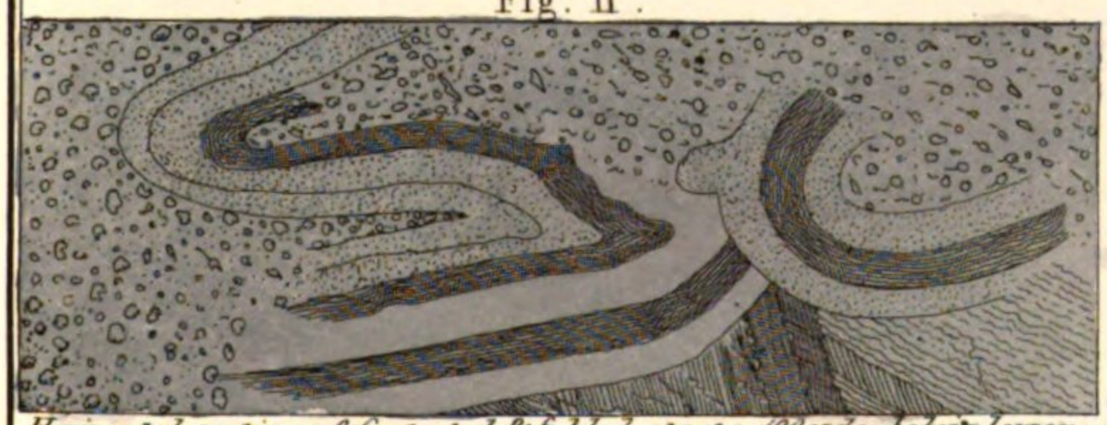
Same Contorted ½ mile below Rhinebeck Landing.

Fig. 10.



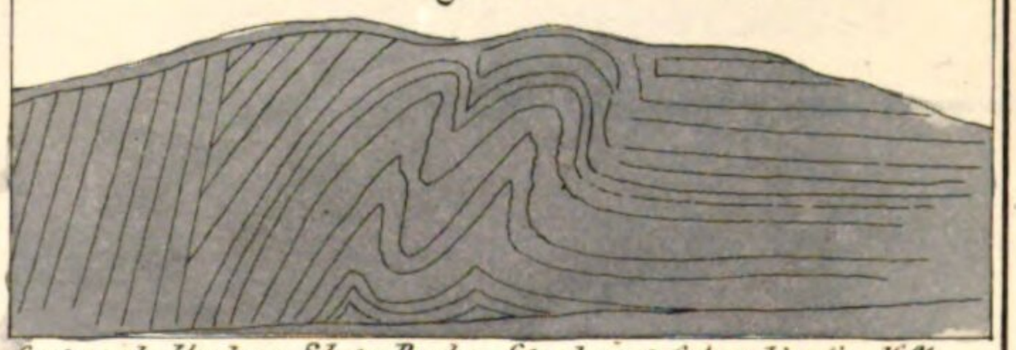
Little below Rhinebeck Landing and also 3½ m. above Hyde Park.

Fig. 11.



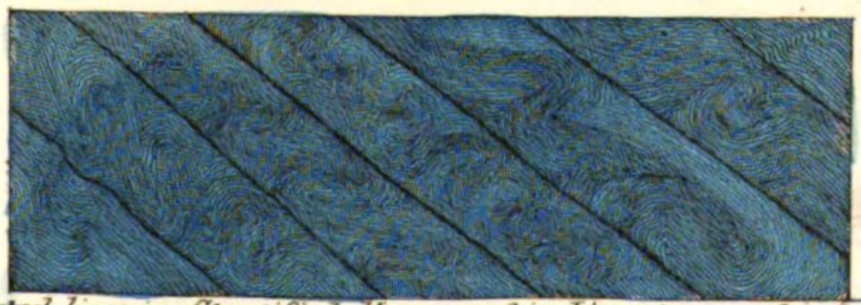
Horizontal section of Contorted & Folded strata 100 yds below lower Red Hook Landing Dutchess Co. N. Y.

Fig. 12.



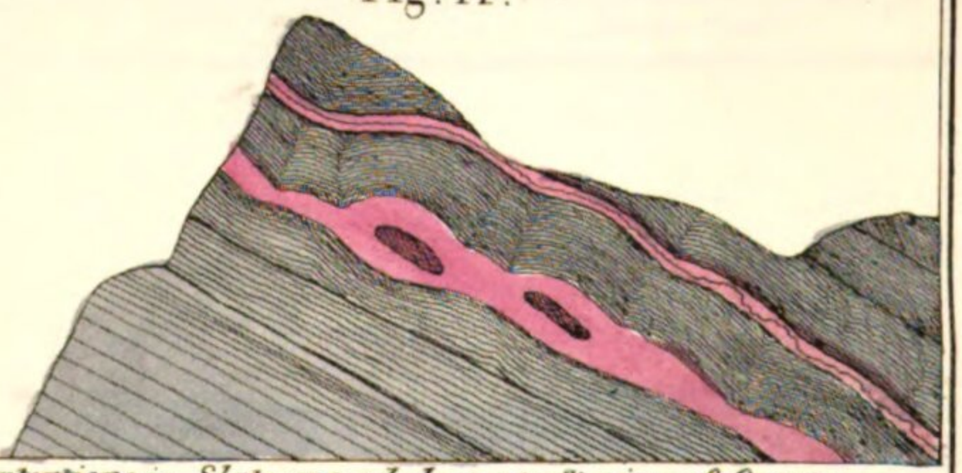
Contorted Hudson Slate Rocks Stockport Columbia Co. N. Y.

Fig. 13.



Contorted lines in Stratified Metamorphic Limestone on the shore between Peekskill & Verplancks Pt. Westchester Co. N. Y

Fig. 14.



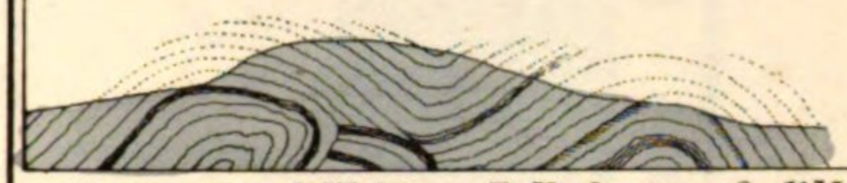
Contortions in Slate caused by nests & veins of Quartz Hillsdale Slate Quarries Columbia Co. N. Y.

T. Seymour Jr fc.

Lith. of Endicott N.Y.

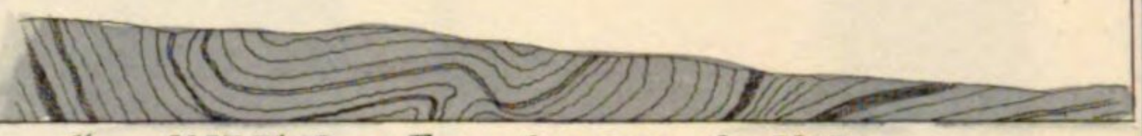
Hudson slate Contortions on the main axis. PLATE II.

Fig. 1.



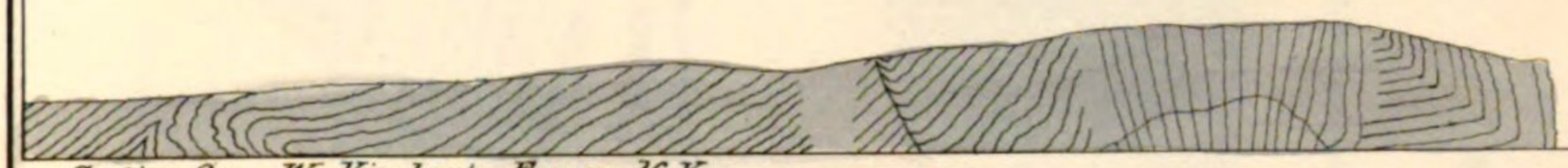
Section 1¼ m. N.W. Cohoes Falls Saratoga Co. N.Y.

Fig. 2.



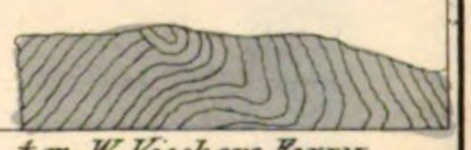
½ m. N.W. Vischers Ferry Saratoga Co. N.Y.

Fig. 3.



Section 2 m. W. Vischer's Ferry N.Y.

Fig. 4.

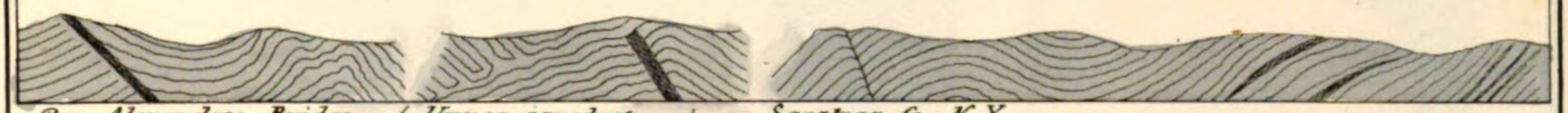


¼ m. W. Vischers Ferry.

Fig. 5.

Fig. 6.

Fig. 7.



2 m. Alexanders Bridge (Upper aqueduct) Saratoga Co N.Y.

Fig. 8.

Fig. 9.

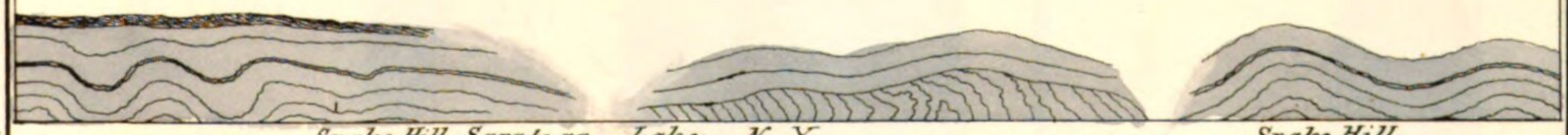


Snake Hill, Saratoga Lake Saratoga Co. N.Y.

Fig. 10.

Fig. 11.

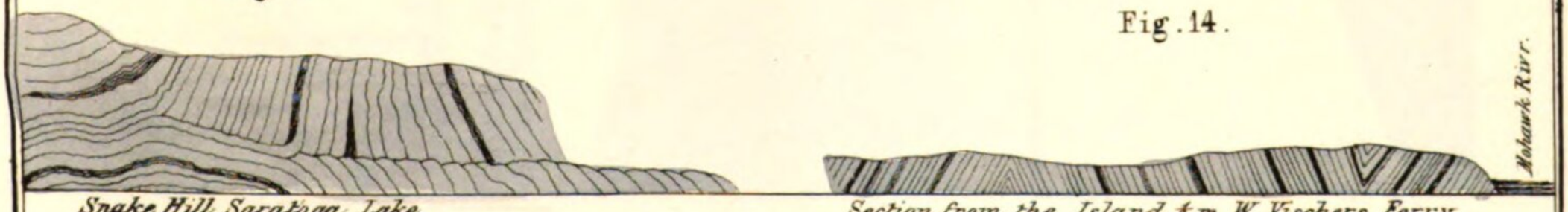
Fig. 12.



Snake Hill Saratoga Lake N.Y. Snake Hill.

Fig. 13.

Fig. 14.



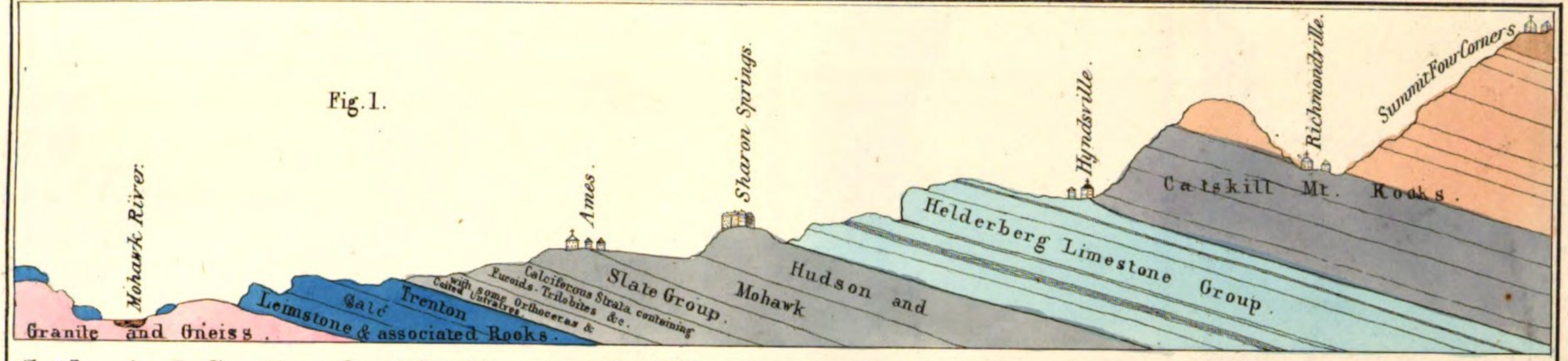
Snake Hill Saratoga Lake

Section from the Island ¼ m. W Vischers Ferry.

T. Seymour Jr. fc.

Lith. of Endicott N.Y.

Fig. 1.



Geological Section from the Noses on the Mohawk, to Summit Four Corners in Schoharie Co. N.Y.

Fig. 2.

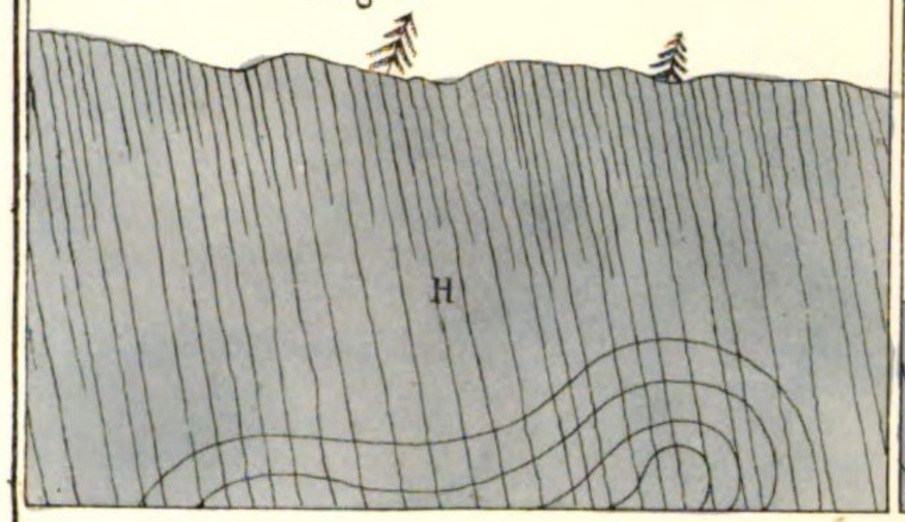


Fig. 3.

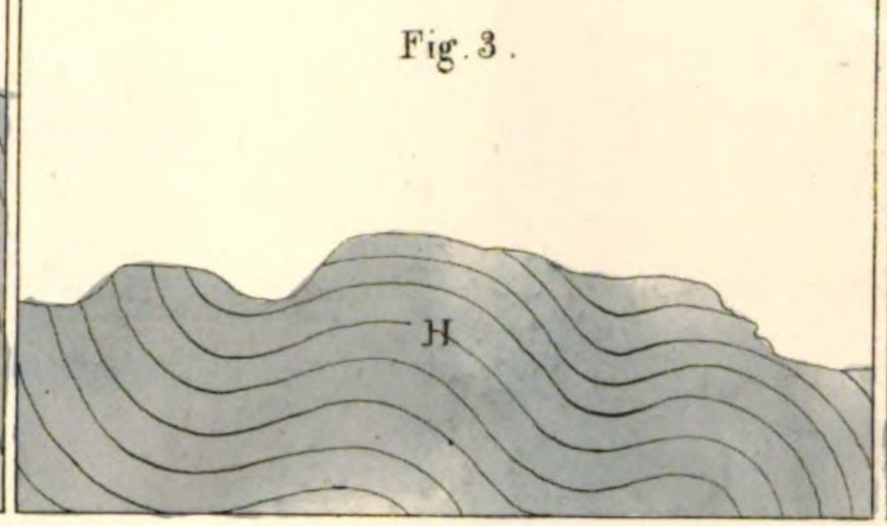


Fig. 4.

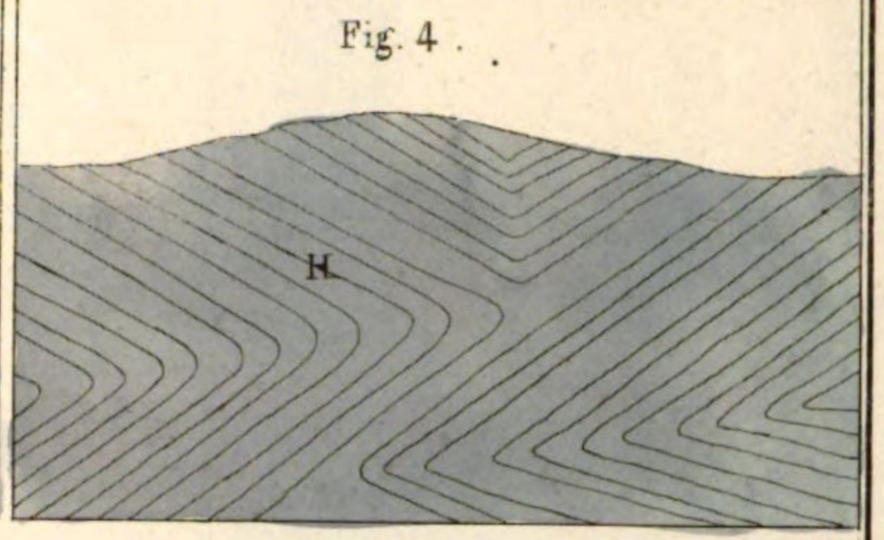


Fig. 5.

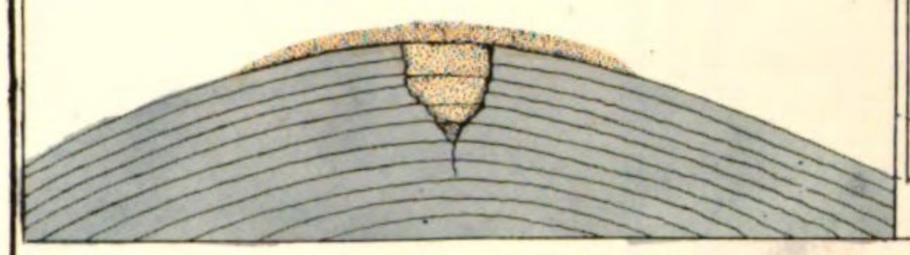


Fig. 6.

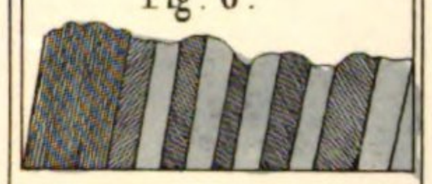


Fig. 7.

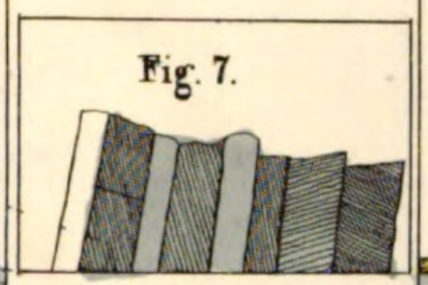
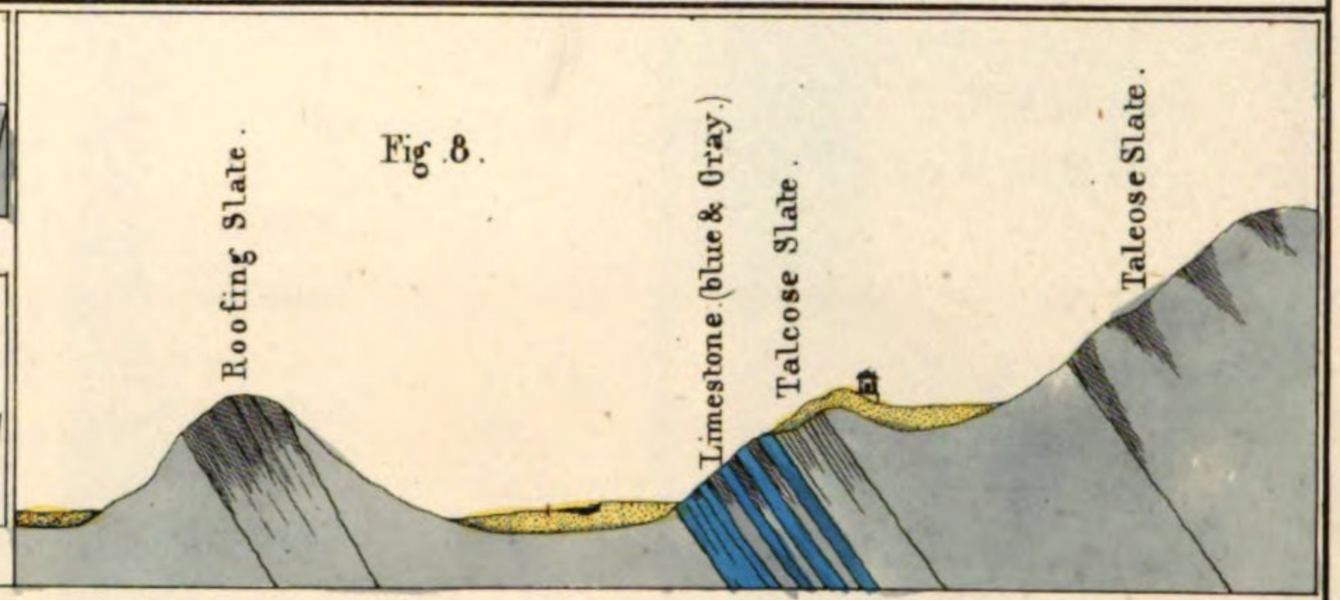
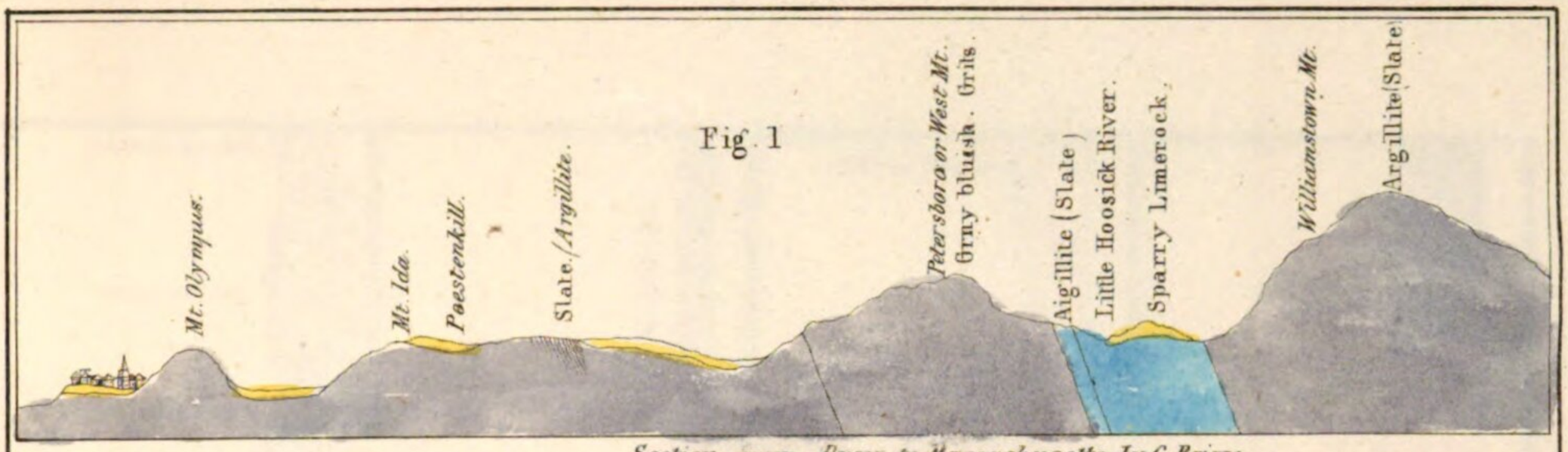


Fig. 8.



Lith. of Endicott New York

Fig. 1



Section from Troy to Massachusetts by C. Briggs.

Fig. 2 .

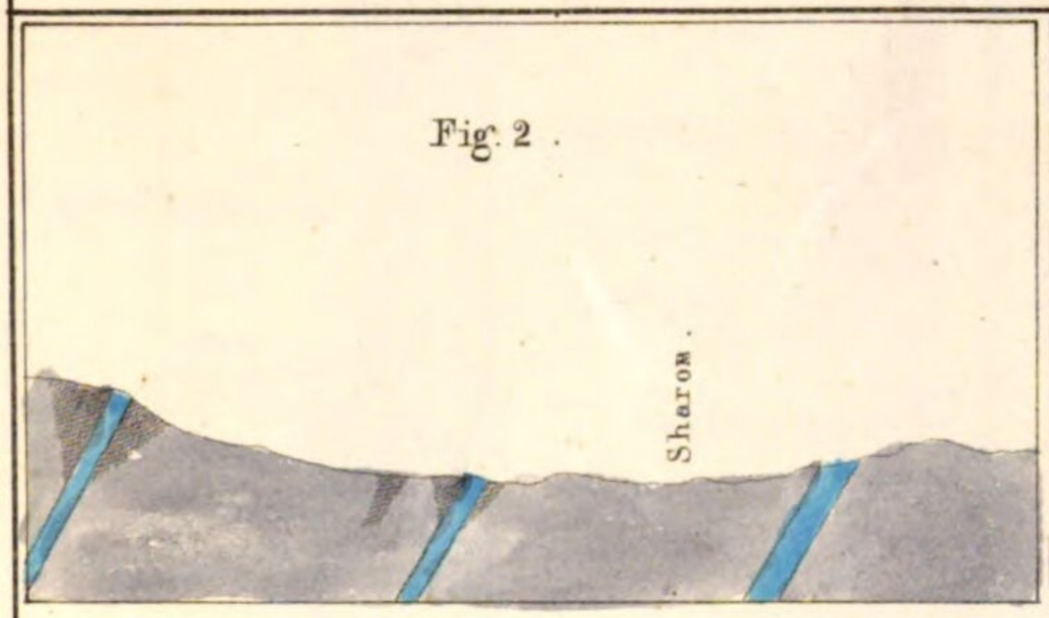
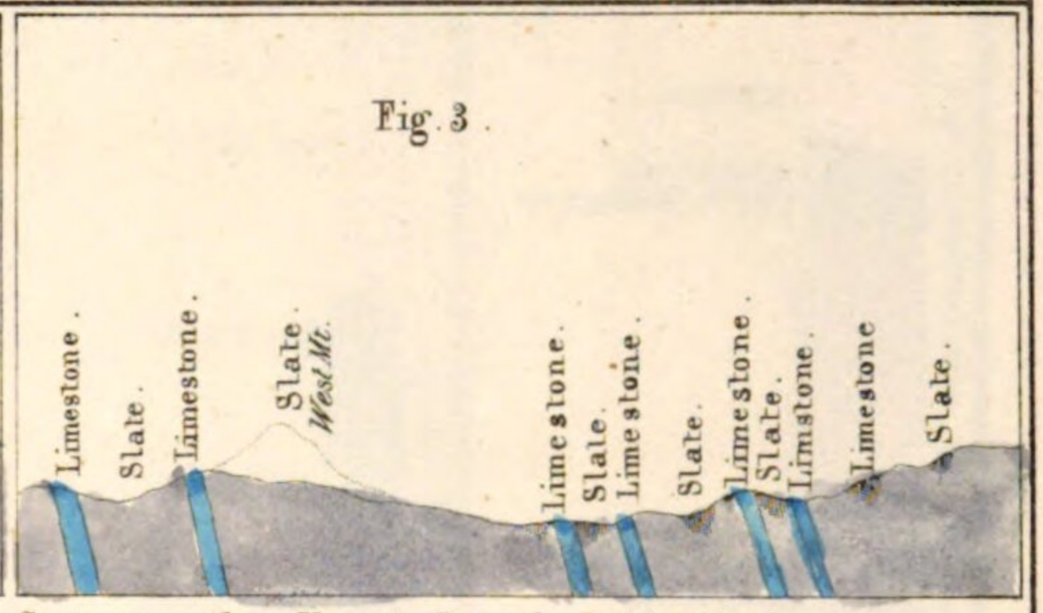
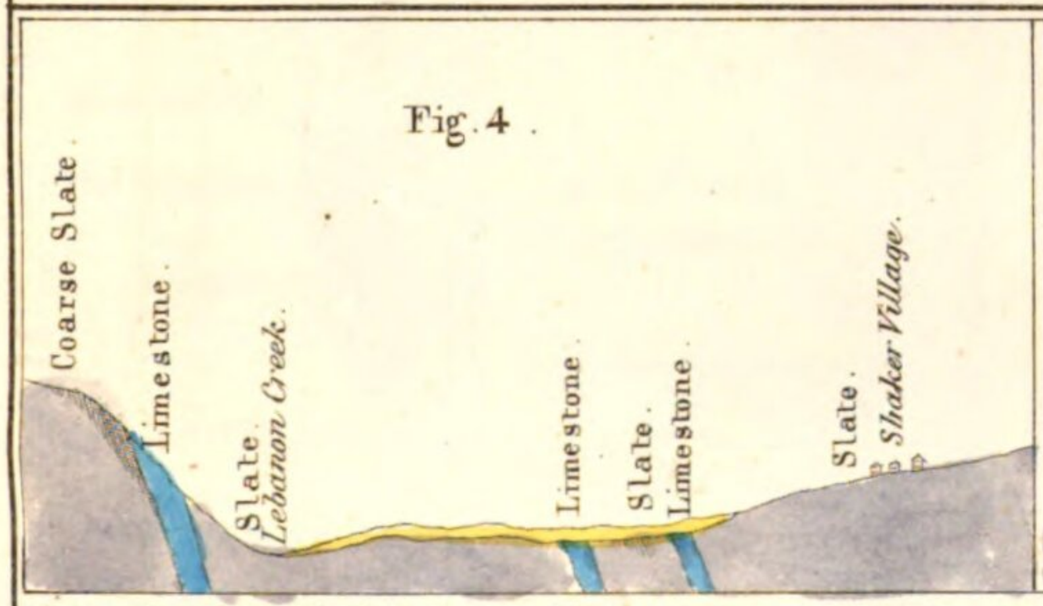


Fig. 3 .



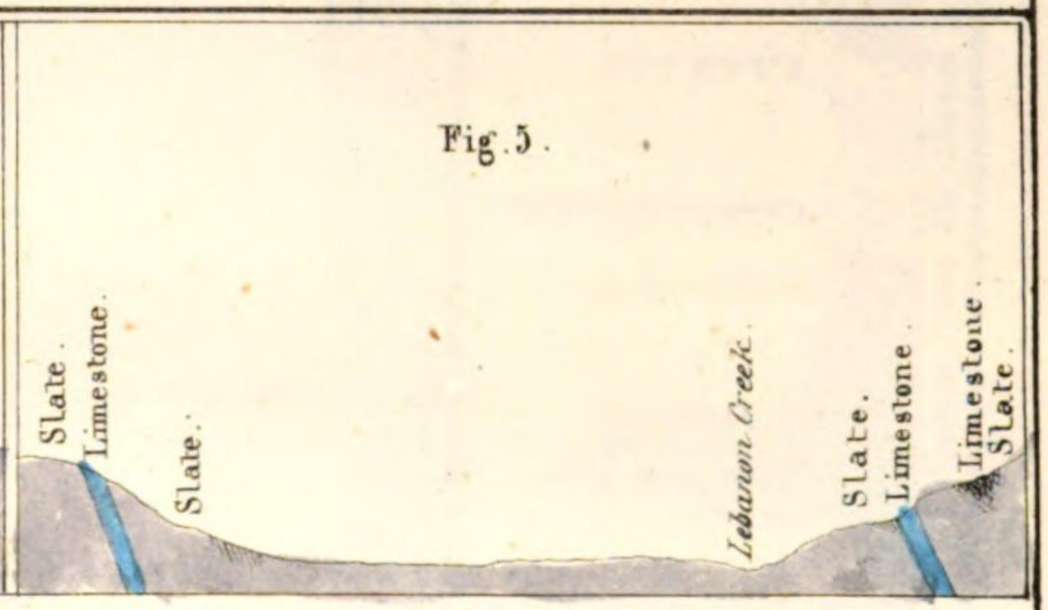
Section across the valley at Stone Creek Columbia Co.

Fig. 4 .



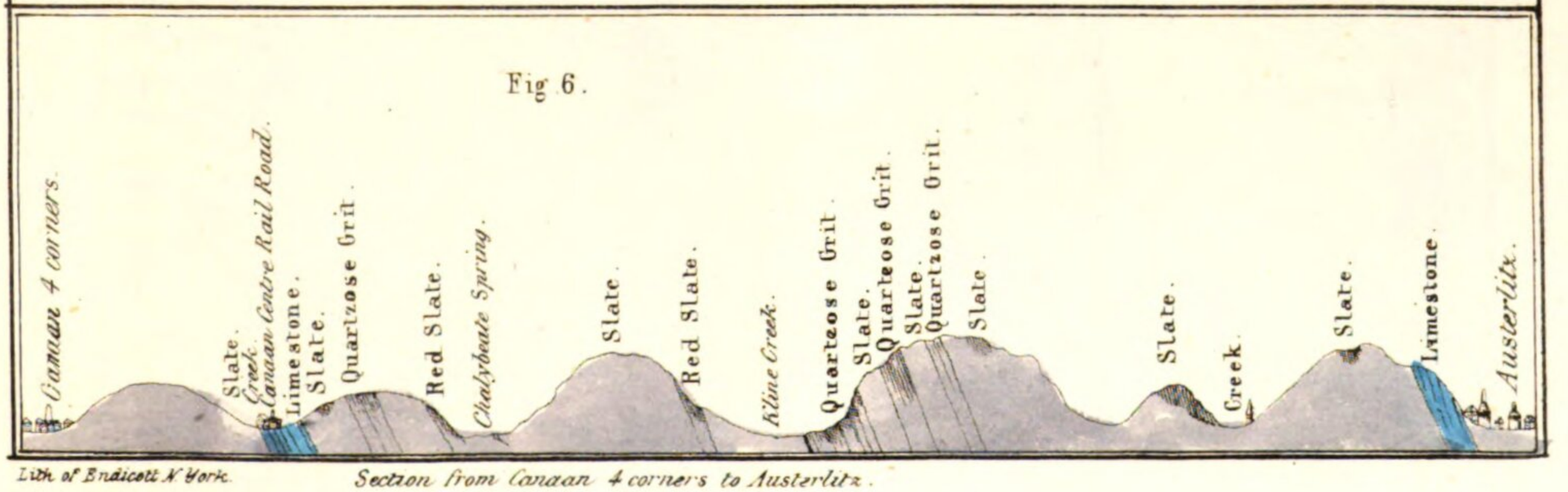
Section through the Medical Garden of the Middle Shaker Family New Lebanon.

Fig. 5 .



Section S of the S. Shaker Family New Lebanon N. Y.

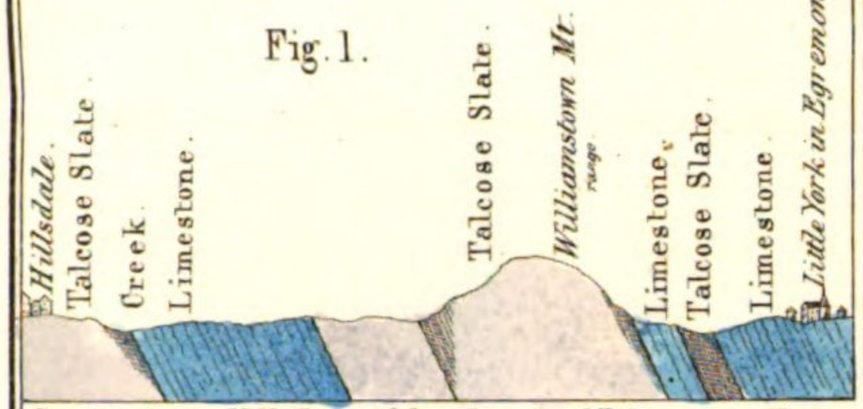
Fig 6.



Lith of Endicott N York.

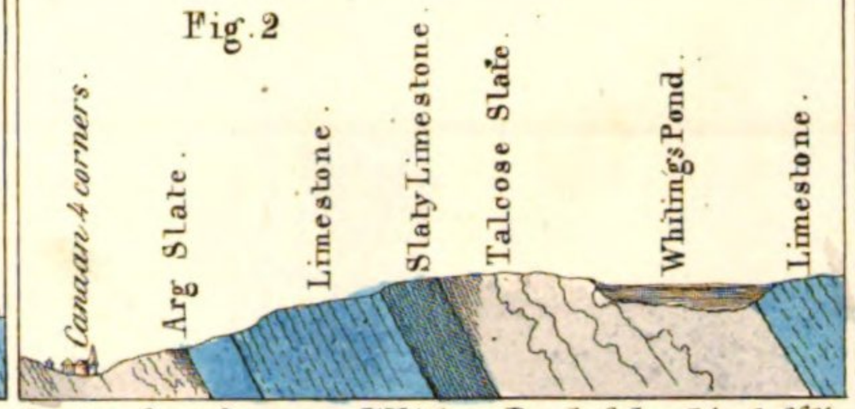
Section from Canaan 4 corners to Austerlitz.

Fig. 1.



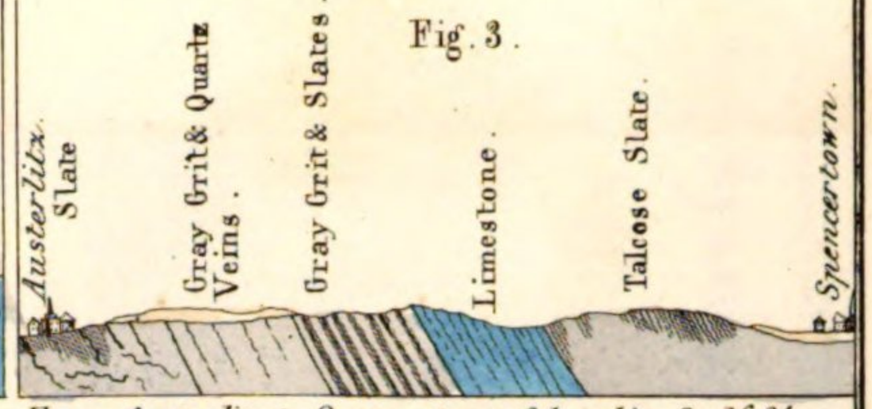
Section from Hillsdale Columbia Co. to N.Y. Egremont Mass.

Fig. 2



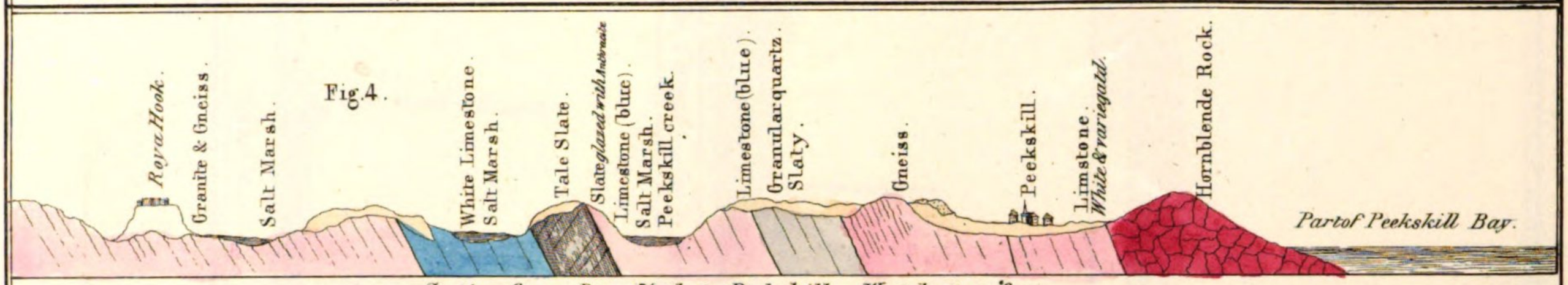
Section from Canaan to Whitings Pond Columbia Co. N.Y.

Fig. 3.



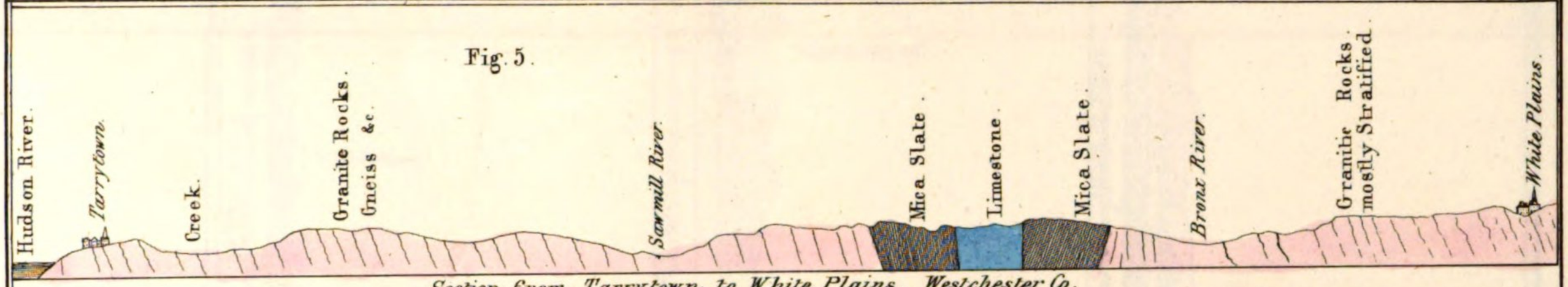
From Austerlitz to Spencertown Columbia Co. N. Y.

Fig. 4.



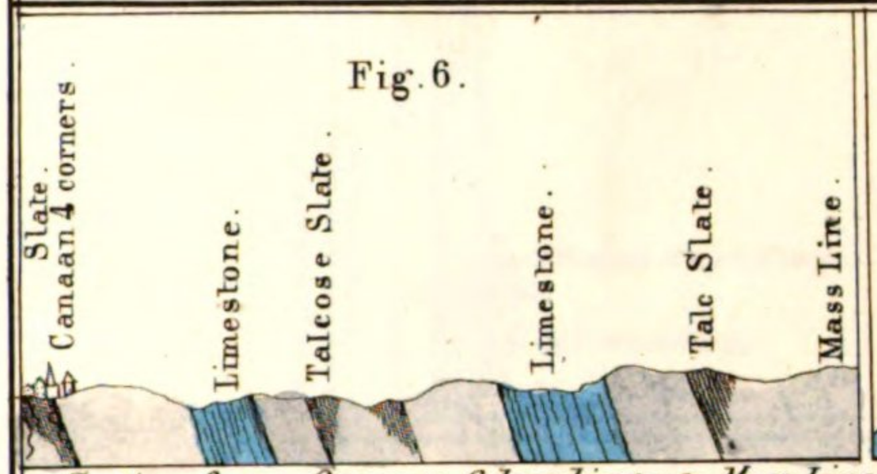
Section From Royal Hook to Peekskill. Westchester Co.

Fig. 5.



Section from Tarrytown to White Plains. Westchester Co.

Fig. 6.



Section from Canaan Columbia Co. to the Mass Line.

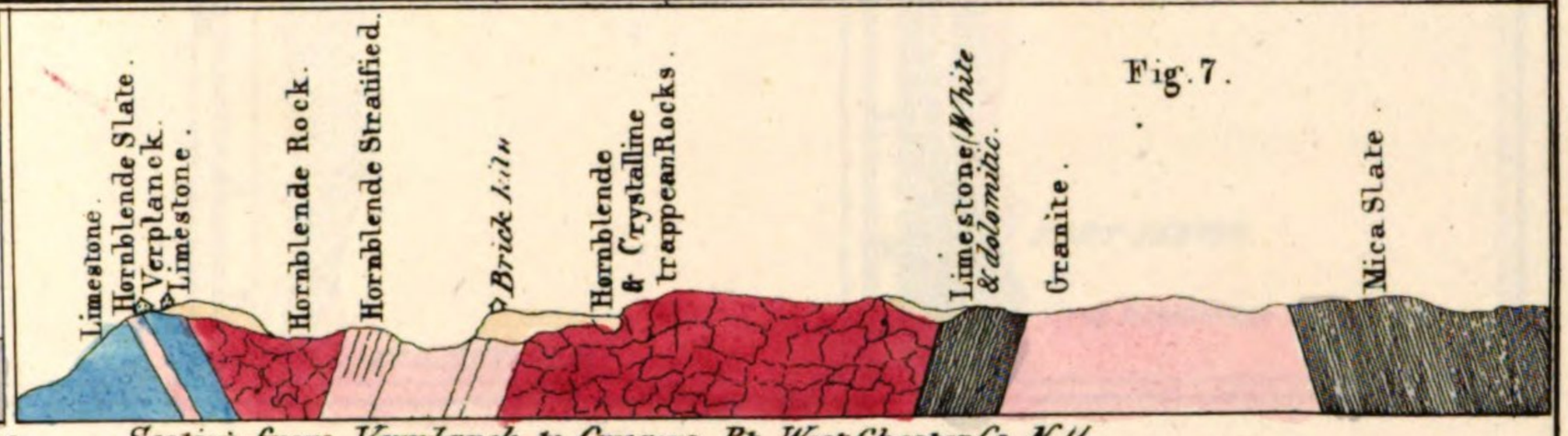


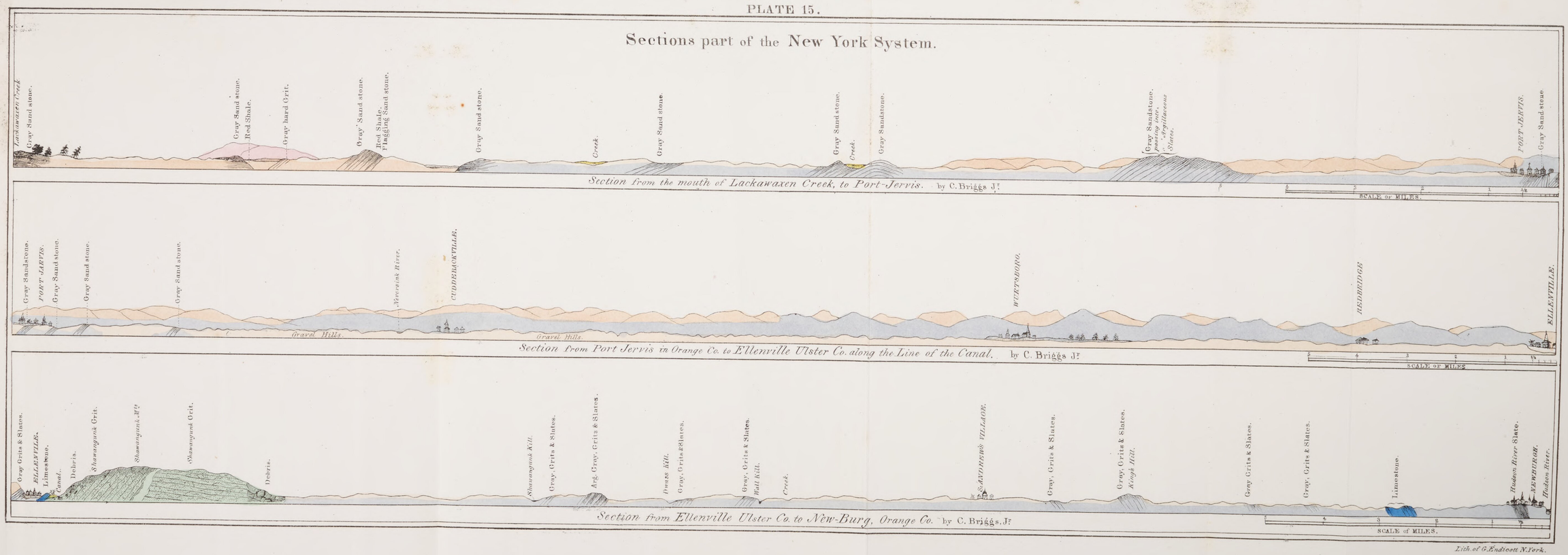
Fig. 7.

Section from Verplanck to Crugers Pt. West Chester Co. N.Y.

Lith. of Endicott N. York.

PLATE 15.

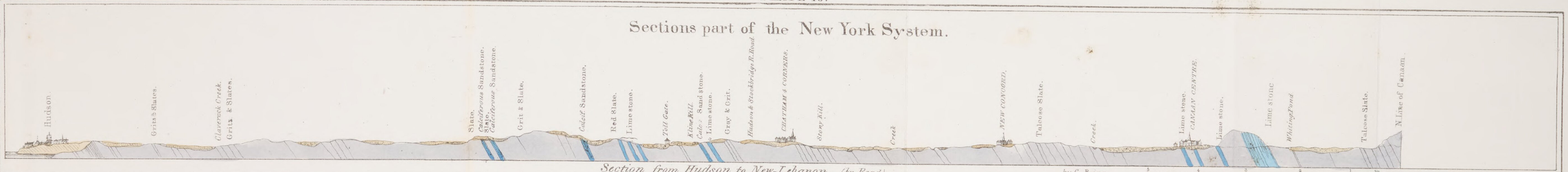
Sections part of the New York System.



Lith. of G. Endicott N. York.

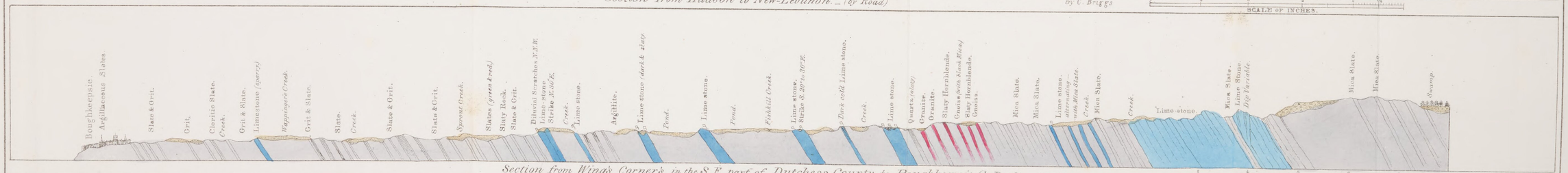
PLATE 16.

Sections part of the New York System.



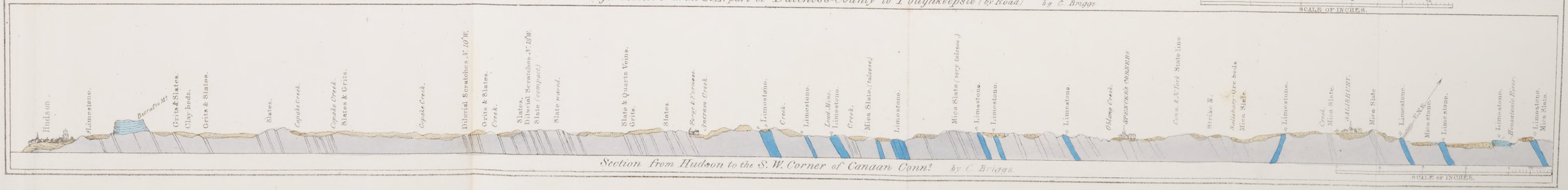
Section from Hudson to New-Lebanon. (by Road) by C. Briggs

SCALE OF INCHES.



Section from Wing's Corners in the S.E. part of Dutchess-County to Poughkeepsie (by Road) by C. Briggs

SCALE OF INCHES.

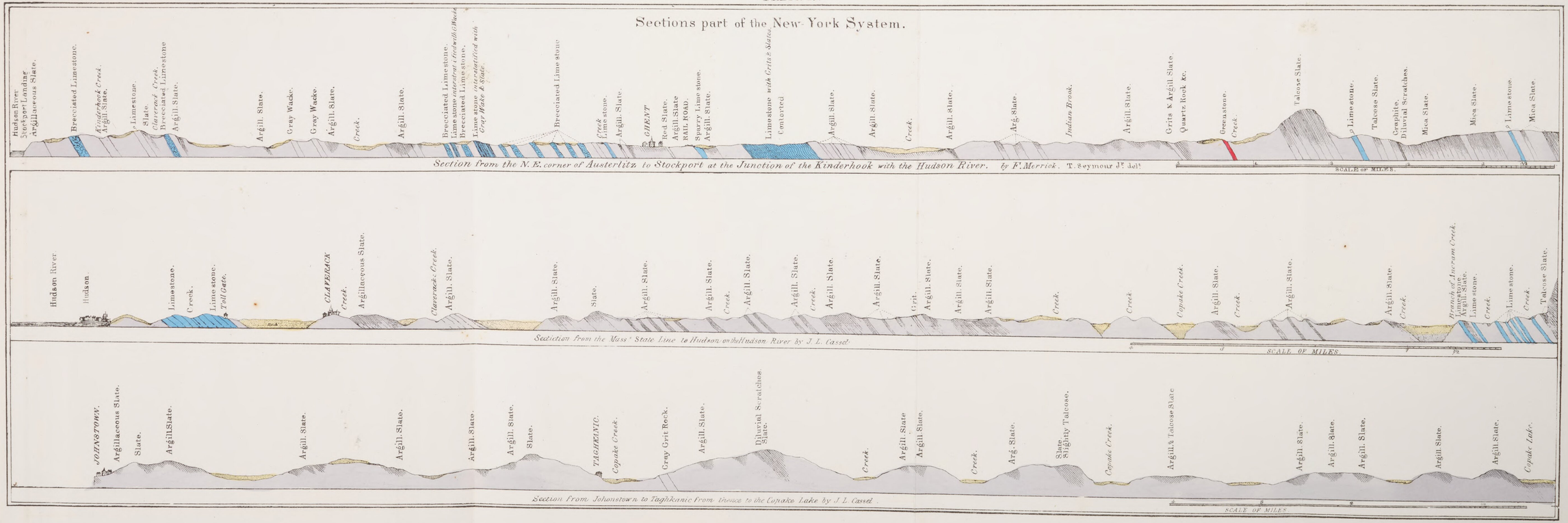


Section from Hudson to the S.W. Corner of Canaan Connt by C. Briggs.

SCALE OF INCHES.

Lith. of C. Bradford N. York.

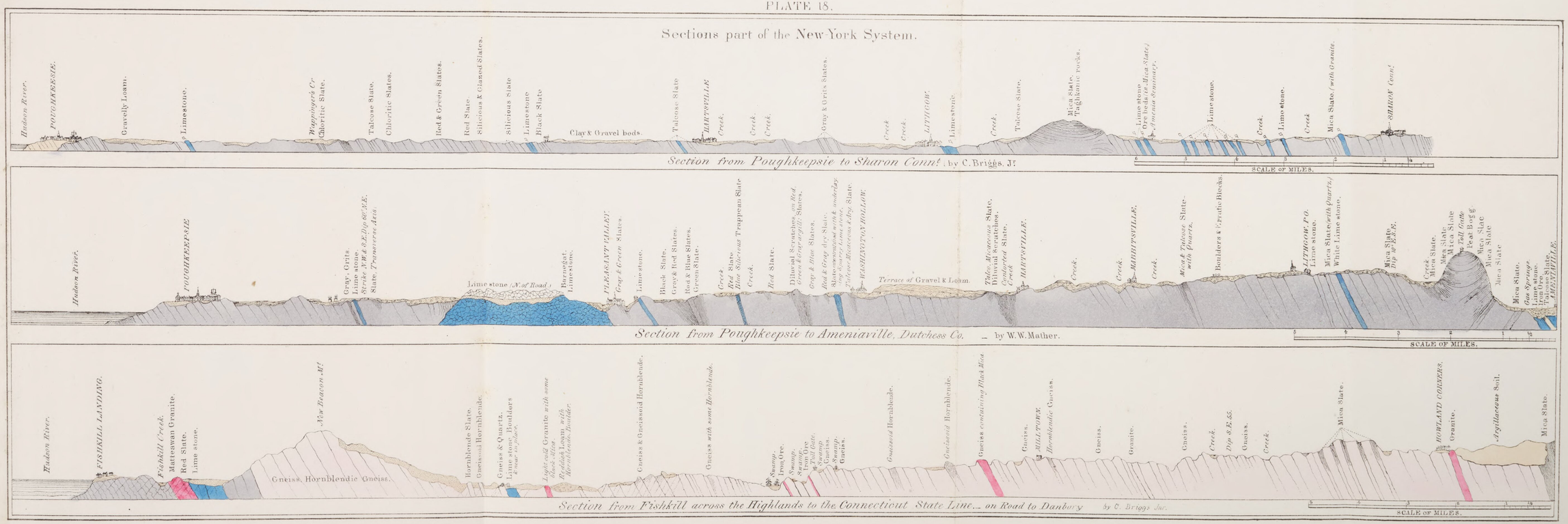
Sections part of the New-York System.



Lith. of Endicott N. York.

PLATE 18.

Sections part of the New-York System.



Lith. of Bradford N. York.

PLATE 19.

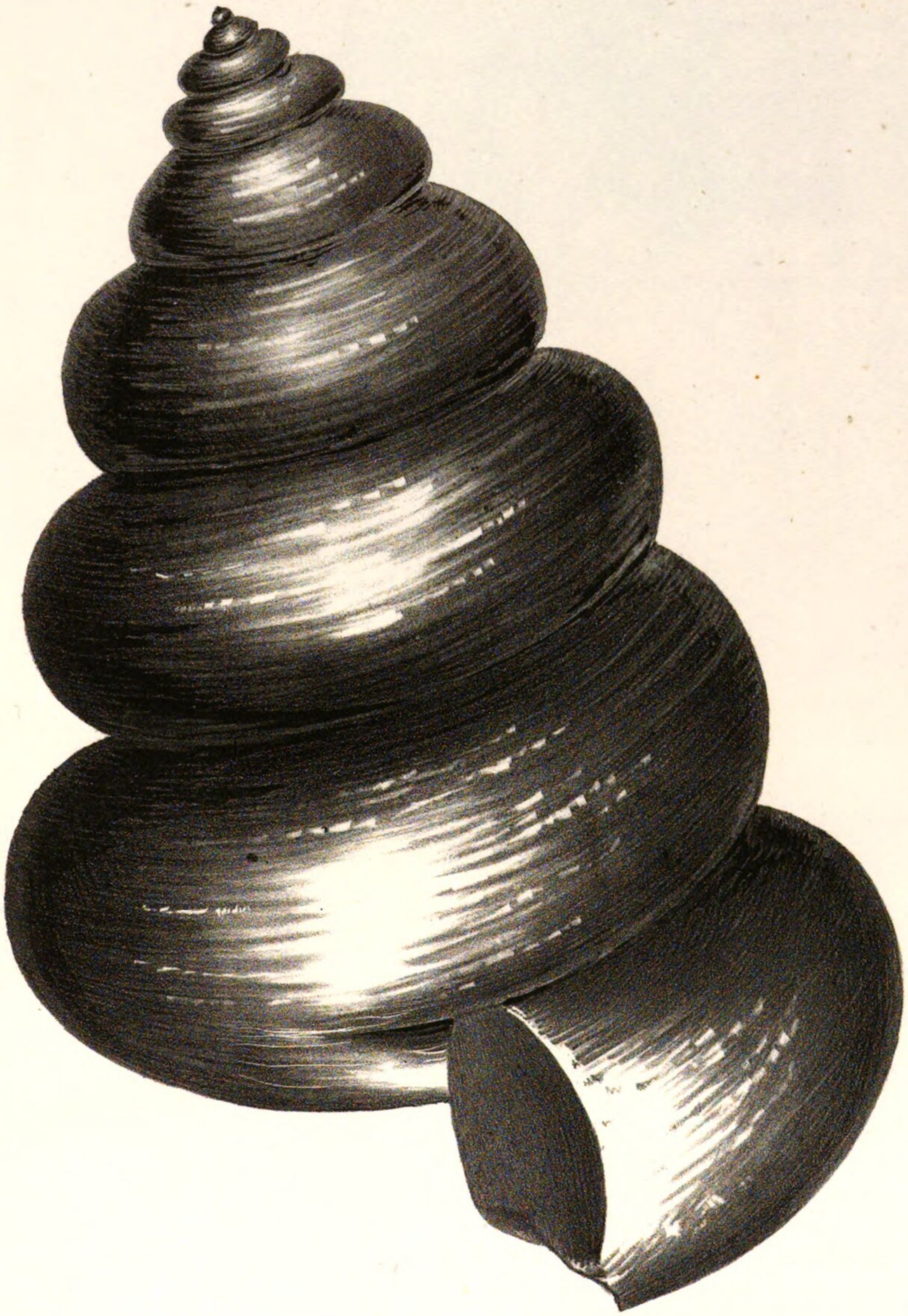


Lith. of Endicott New York.

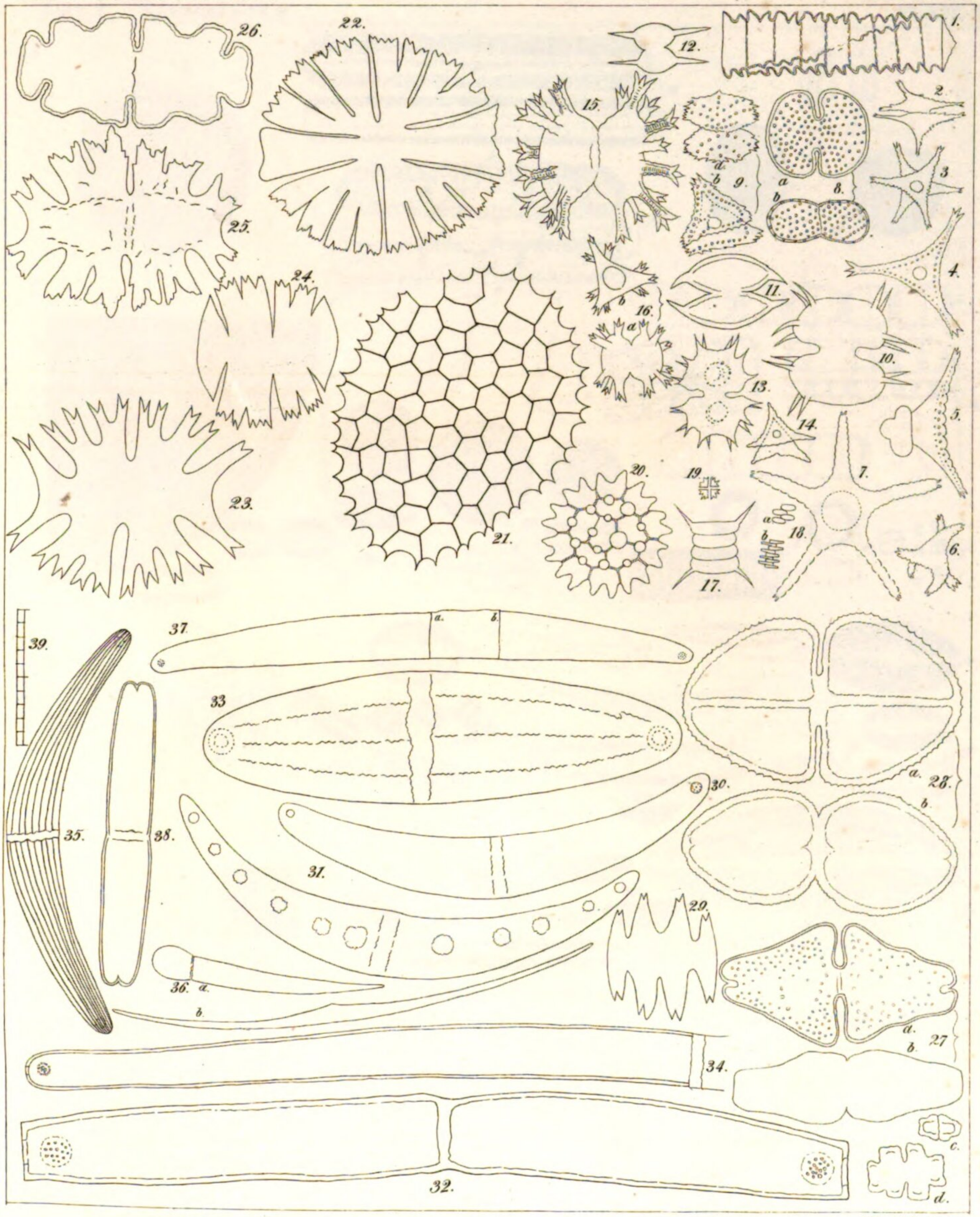
PLATE 19.



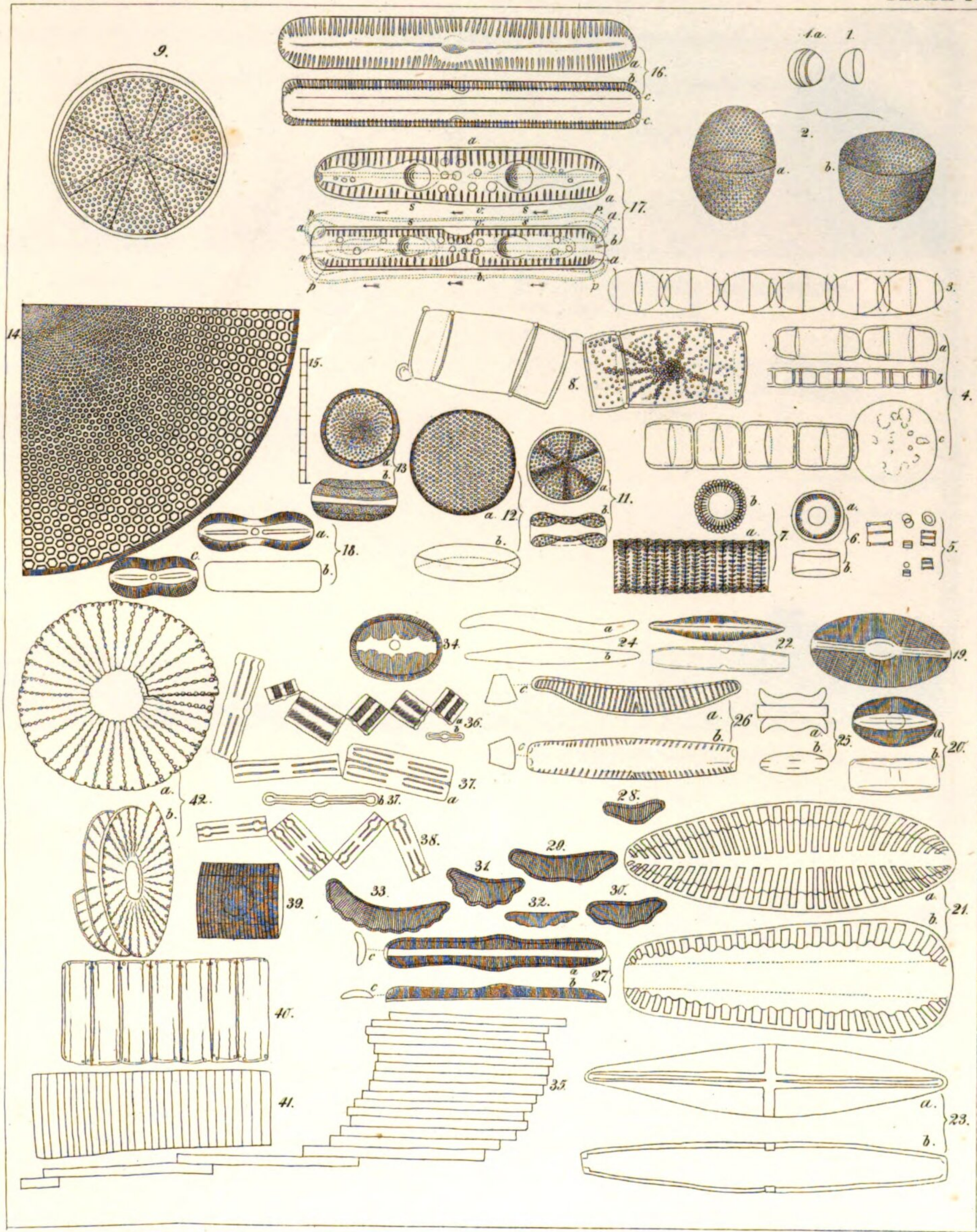
Lith. of Endicott New York.



Lith. of Endicott New York.



ILLUSTRATIONS TO PROF. J.W. BAILEY'S PAPER ON AMERICAN BACILLARIA. *Lith. of Endicott.*

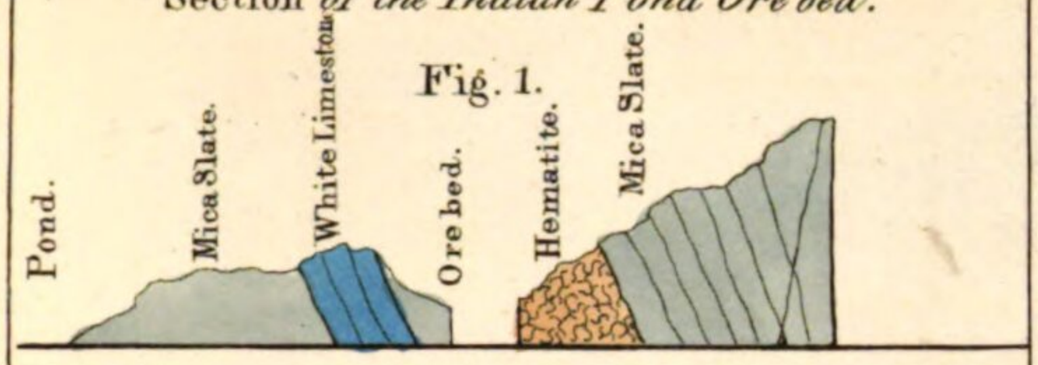


Lith. of Endicott New York.

ILLUSTRATIONS TO PROF. J.W BAILEY'S PAPER ON AMERICAN BACILLARIA.

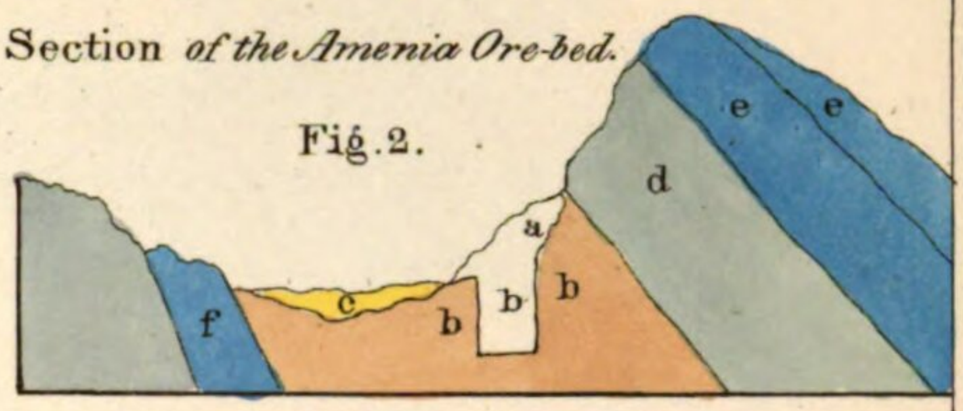
Section *of the Indian Pond Ore bed.*

Fig. 1.



Section *of the Amenia Ore-bed.*

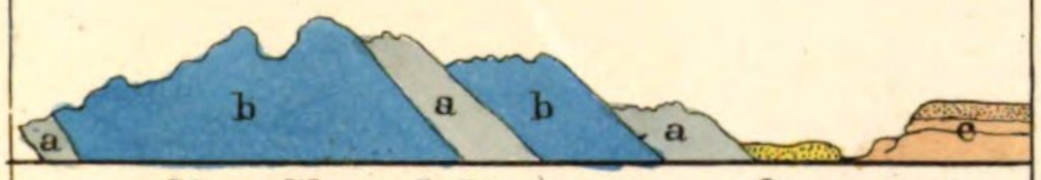
Fig. 2.



a, Decomposed black Slate & Earth.
b, Hematitic Iron Ore.
c, Alluvion.
d, Slate. *(blackish micaceous & talcy.)*
e, Lime-stone. *(whitish bluish & Sandy.)*
f, *(white.)*

Section *of Leedsville M.t Amenia.*

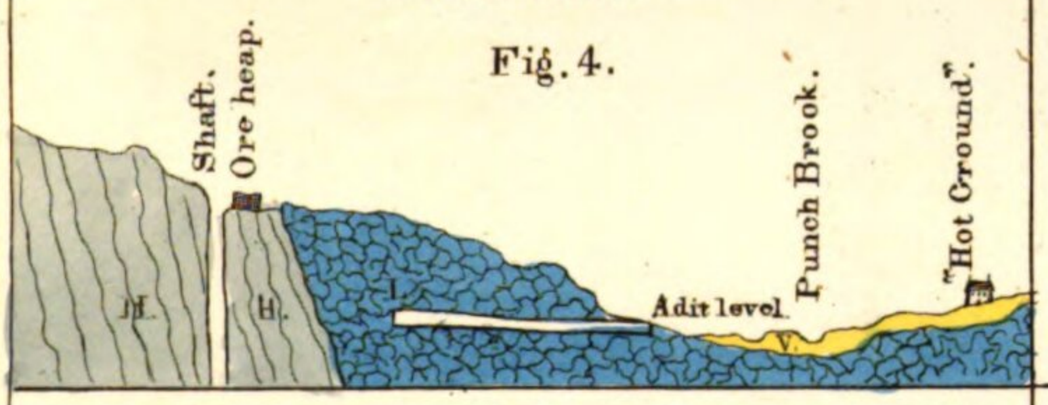
Fig. 3



a, Mica Slate. b, Lime stone. c, Quaternary.

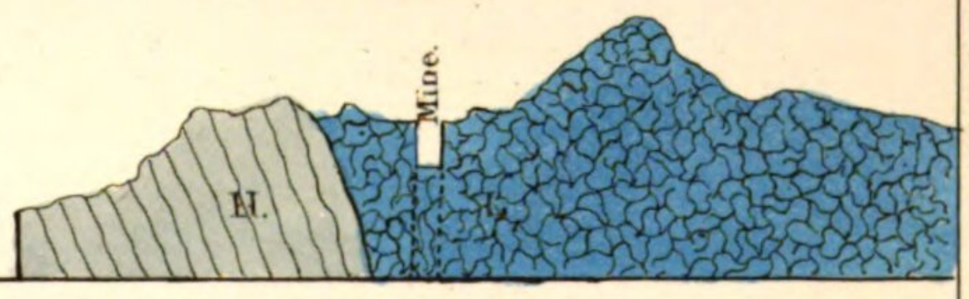
Section *of the Ancram Lead-mine Columbia Co.*

Fig. 4.



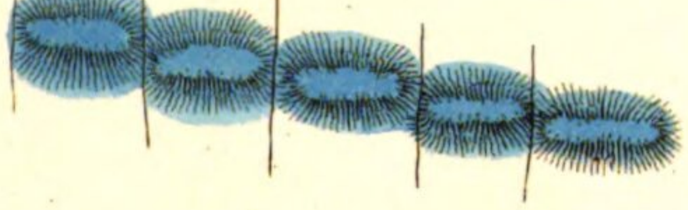
Section *of Bryan & Bookee's Lead mines, in North East Dutchess Co.*

Fig. 5.



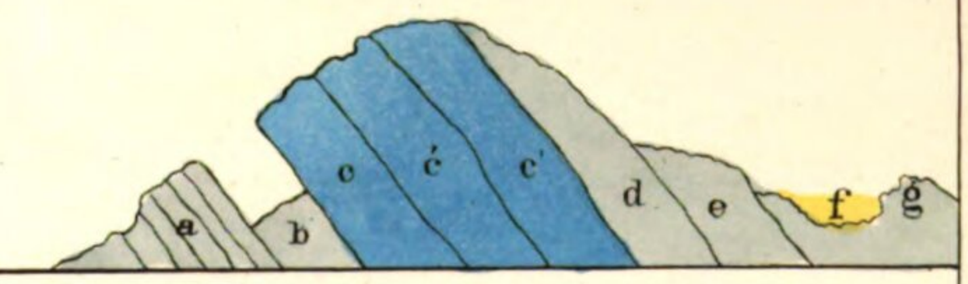
Lateral dislocations of Limestone. Ghent, Col. Co.

Fig. 6.



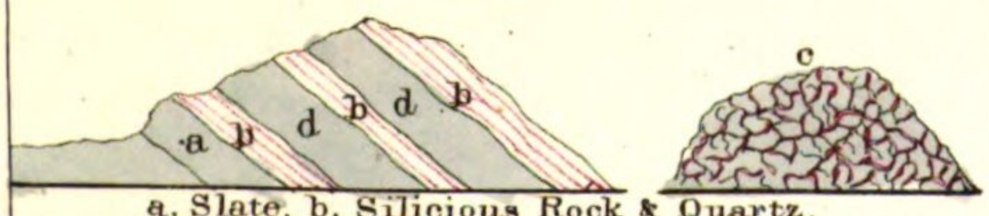
Section *of the Stuyvesant Quarries Columbia Co.*

Fig. 8.



Section *S. of Red rock Columbia.*

Fig. 7.



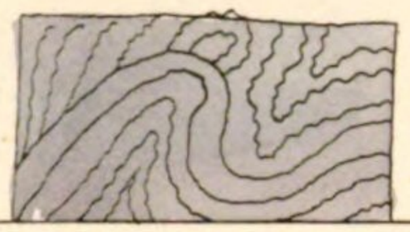
a, Slate. b, Silicious Rock & Quartz.
c, Slate Rock & Grit *injected with Quartz.*

a, Slate *interstratified with Limestone.*
b, Greenish Slate *containing carbonate of lime.*
c, ć, c̀, Limestone breccias.
d, Slate.
e, Crystalline calciferous Grit.
f, Peatbog.
g, Grit Slate.

Lith. of G. Endicott. N. York.

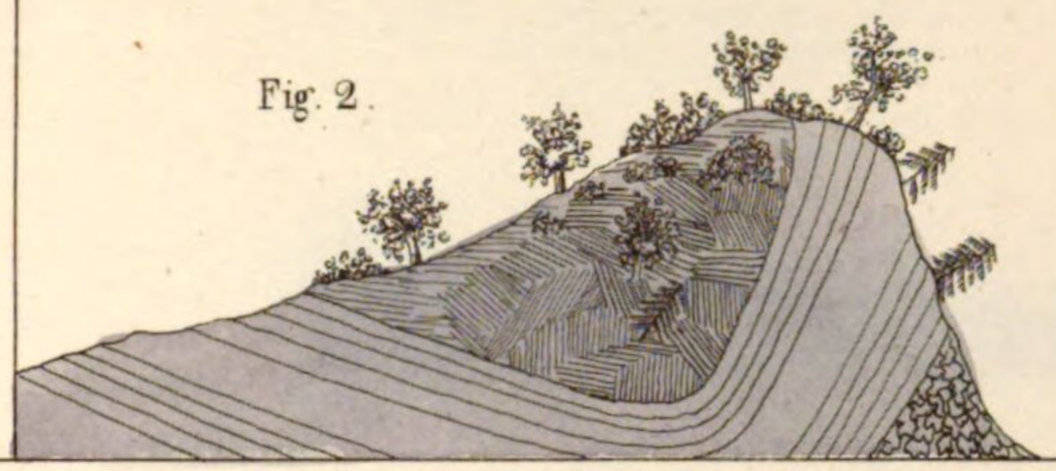
Contortion of Slaty grits Rodgers Island 2. miles N. 40° E. of Catskill.

Fig. 1.



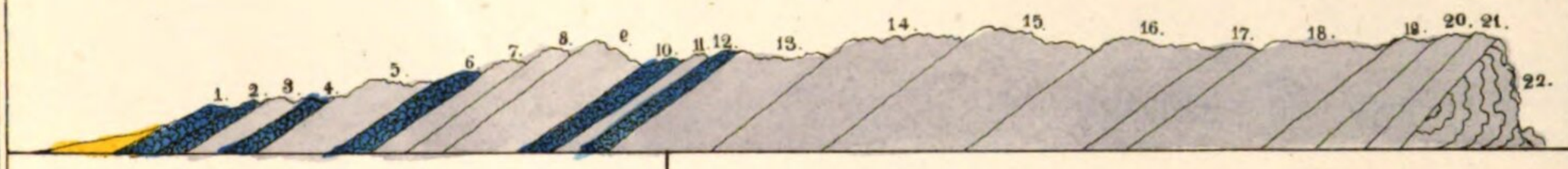
Contorted strata of Hudson slate rocks at Great Neuten Hook.

Fig. 2.



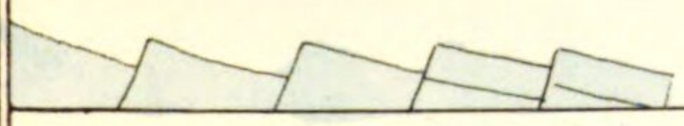
Section *along the Shore of the S.E. part of Great Neuten Hook from the Cove to near the end of the Section in Fig. 2.*

Fig. 3.



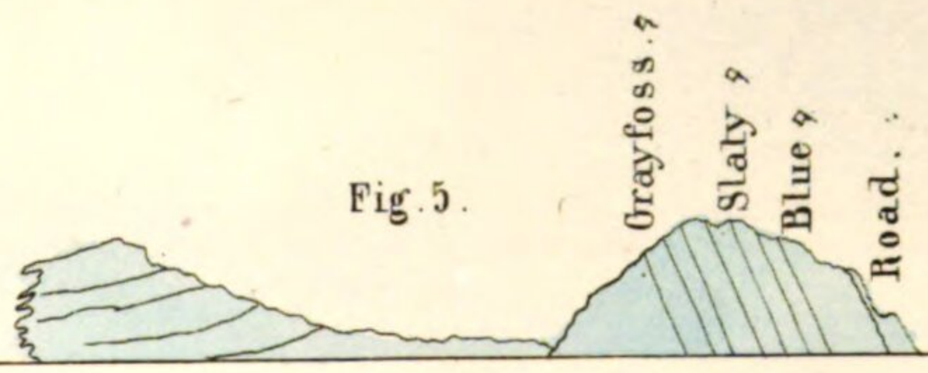
Slight faults on Becrafts Mountain.

Fig. 4.



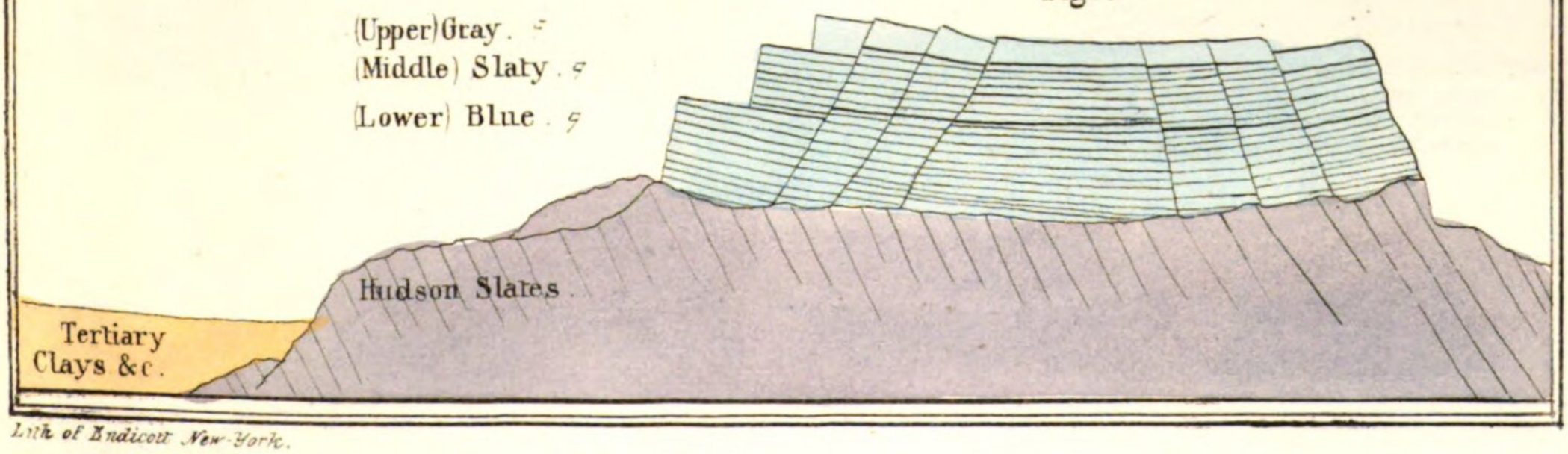
Section *at S.E. end of Becrafts Mt. Overturned Strata.*

Fig. 5.



Section *of Becrafts Mountain near Hudson.*

Fig. 6.



Lith of Endicott New-York.

Dislocation at Barnegat 200 yds SE of the tavern.

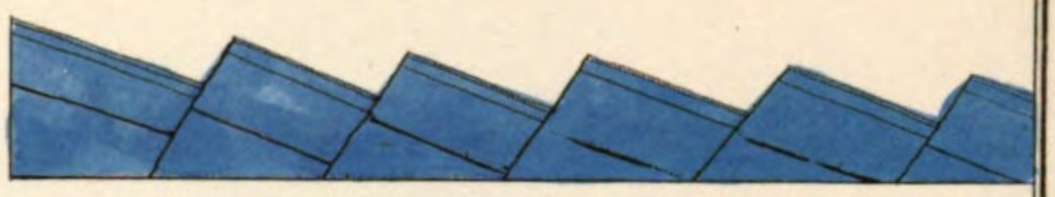
Fig. 1.



a. Gray Sandy Limestone.
b Dark coloured.

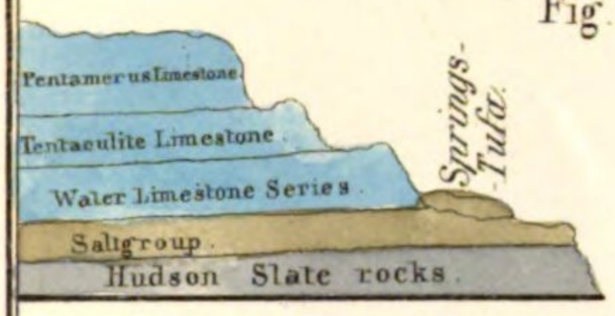
Limestone *ridges caused by faults Barnegat Dutchess Co.*

Fig. 2.



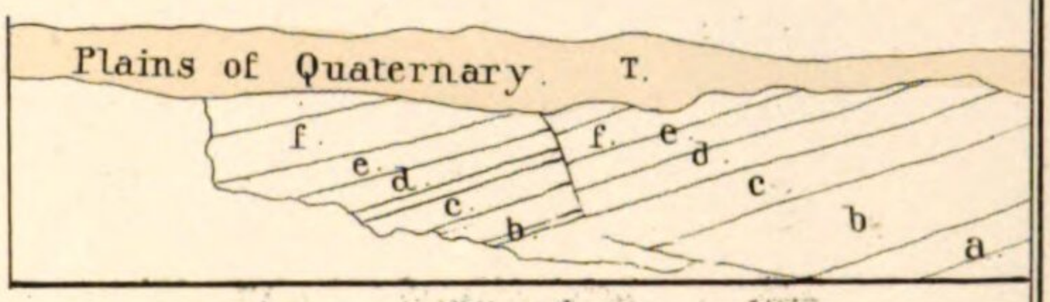
Section *at Sharon springs. Schoharie Co.*

Fig. 3.



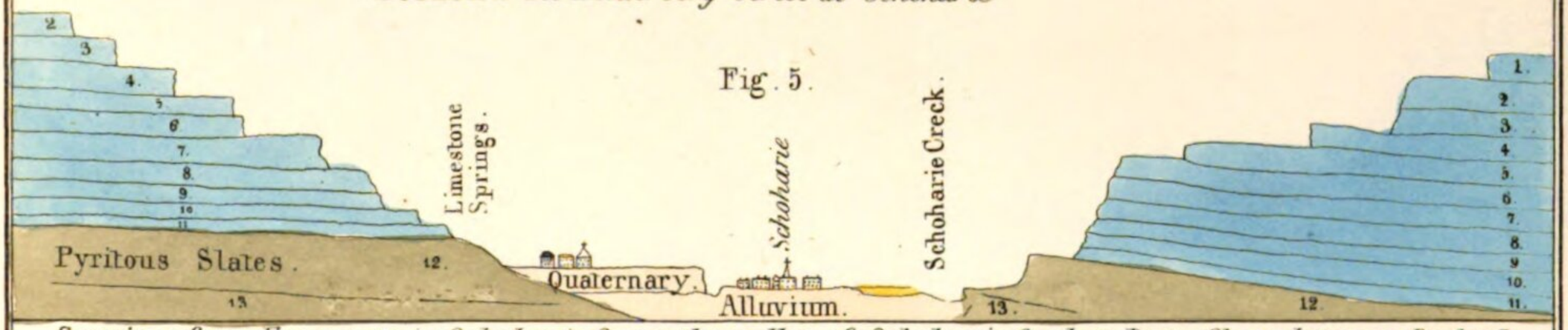
Section *at the High Falls of the Rondout.*

Fig. 4.



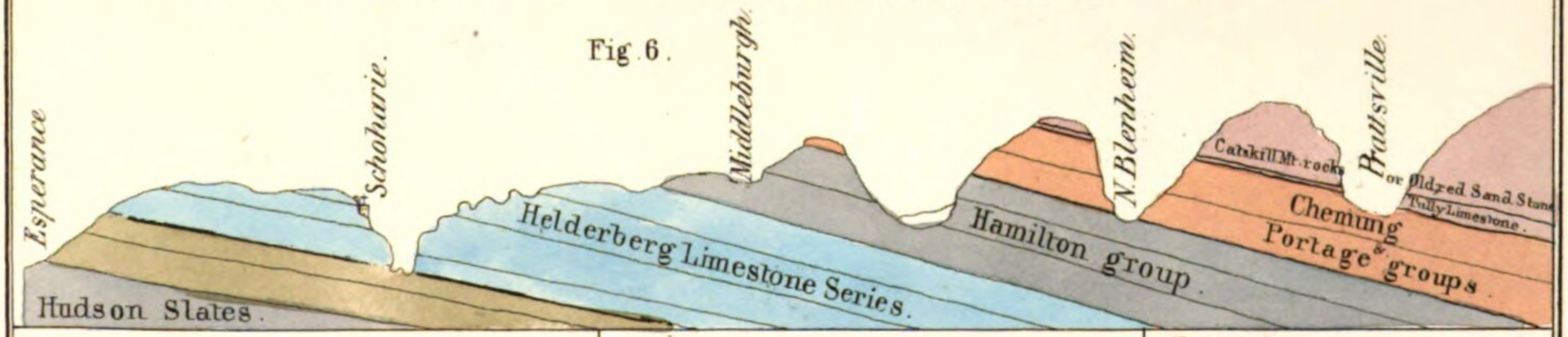
Section *of the Helderberg Series at Schoharie*

Fig. 5.



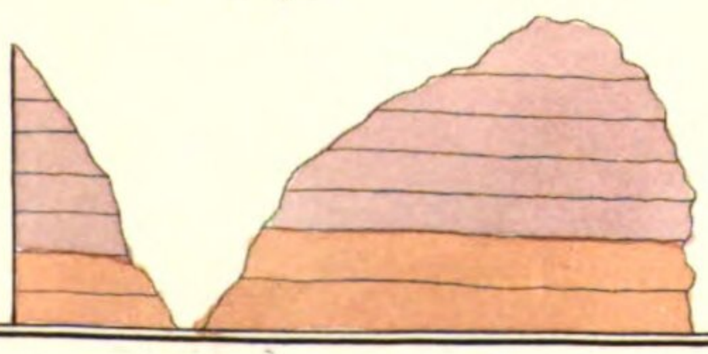
Section *from Esperance in Schoharie Co. up the valley of Schoharie Creek to Deep Clove between Bushnels Tannery Village in Lexington Greene Co. & the Bushkill in Shandaken Ulster Co.*

Fig. 6.



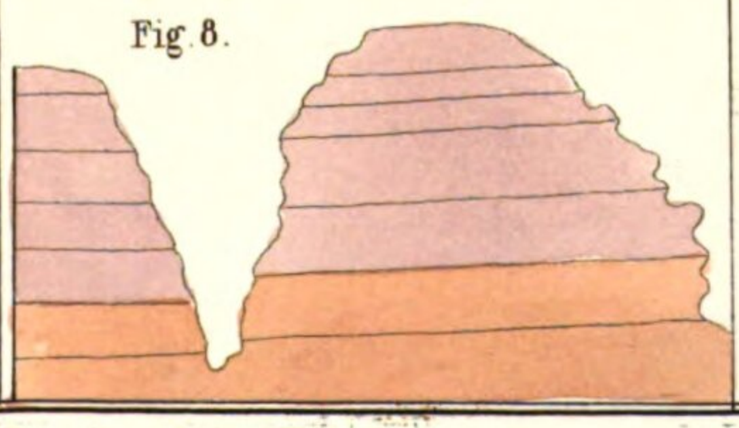
Deep Clove. Ulster Co.

Fig. 7.



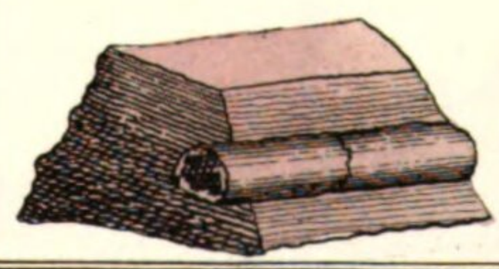
Stone Clove.

Fig. 8.



Fossil Stem in gray grit of the Catskill Mt. rocks 6 inches Diameter Durham.

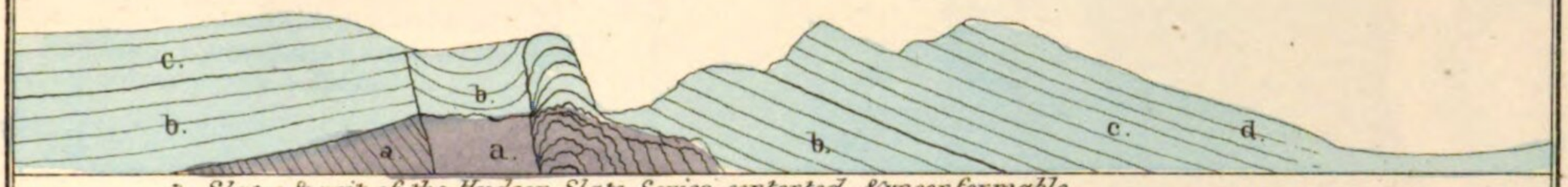
Fig. 9.



Lith. of Endicott New York.

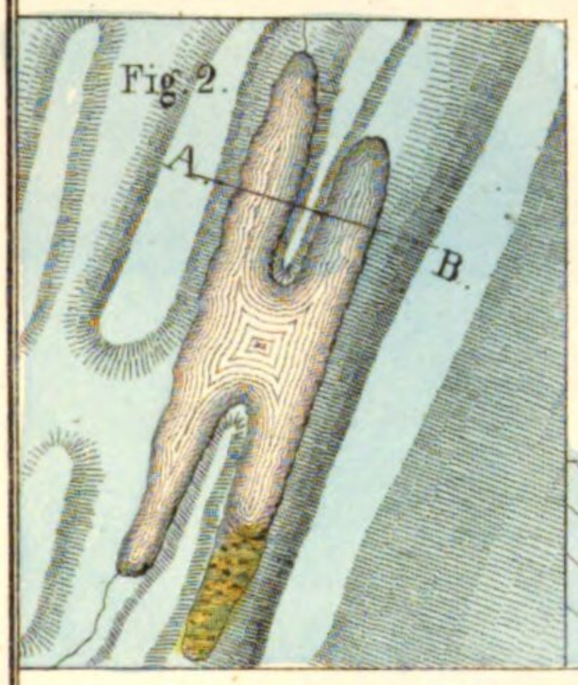
Section *on the Right bank of the Rondout opposite Wilbur Ulster Co.*

Fig. 1.



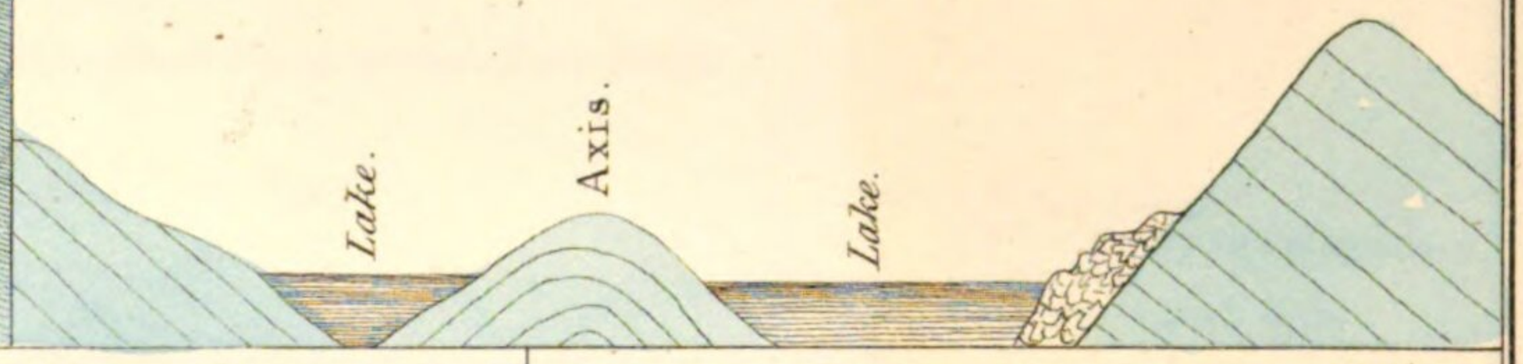
a. Slates & grit of the Hudson Slate Series contorted & unconformable.

Fig. 2.



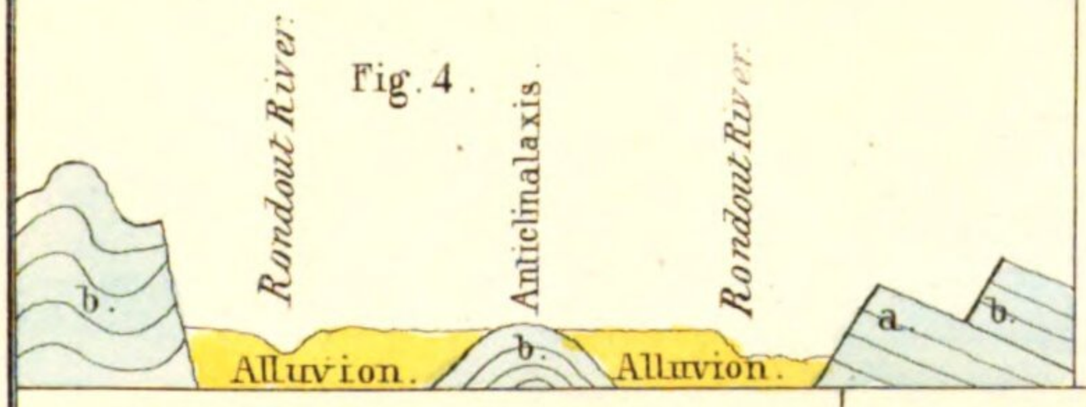
Section *across the axis at Two ponds along the line A.B. of Fig. 2.*

Fig. 3.

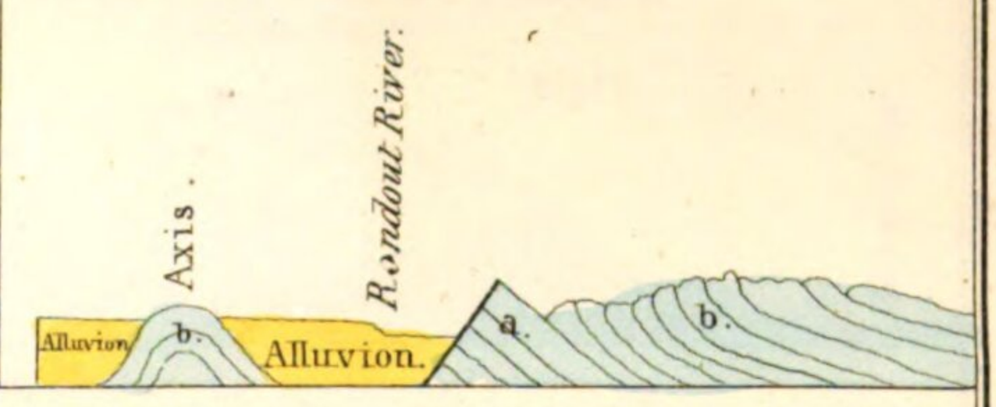


Section *across the Anticlinal axis ½ mile above Lawrenceville Ulster Co.*

Fig. 4.

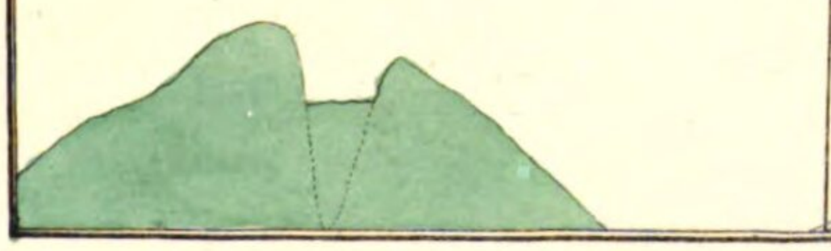


Section *at the West End of the Quarries at Lawrenceville, across the axis.*



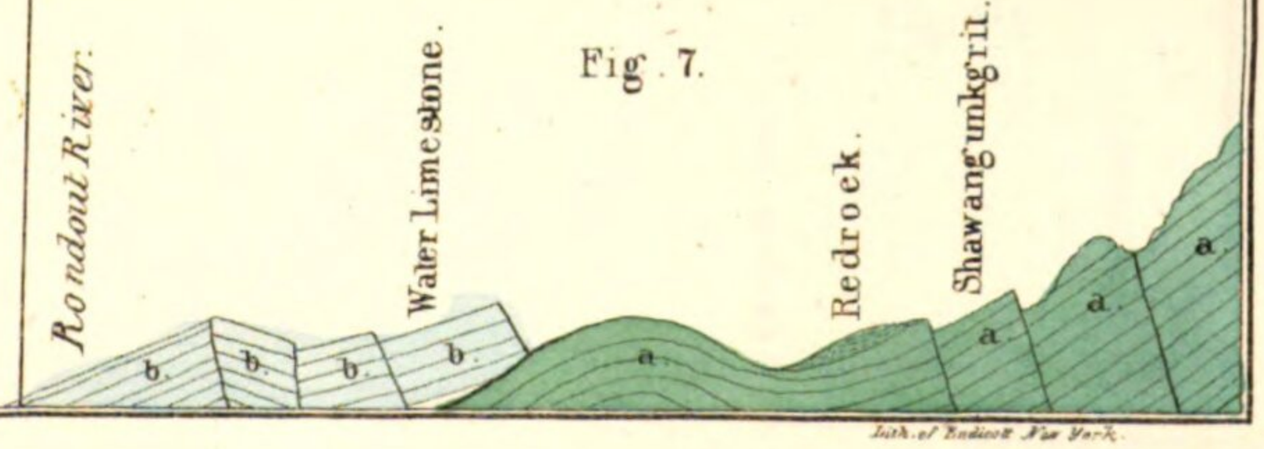
Double fault on the Shawangunk Mt. where the same axis Crosses the Mt.

Fig. 6.



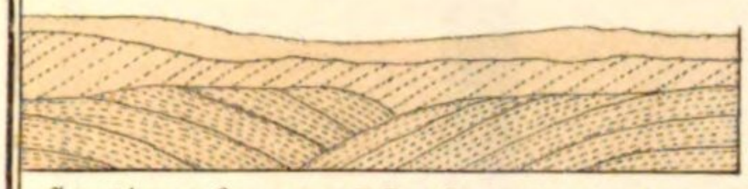
Section *from Rochester to the Shawangunk Mt.*

Fig. 7.



Lith. of Endicott New York.

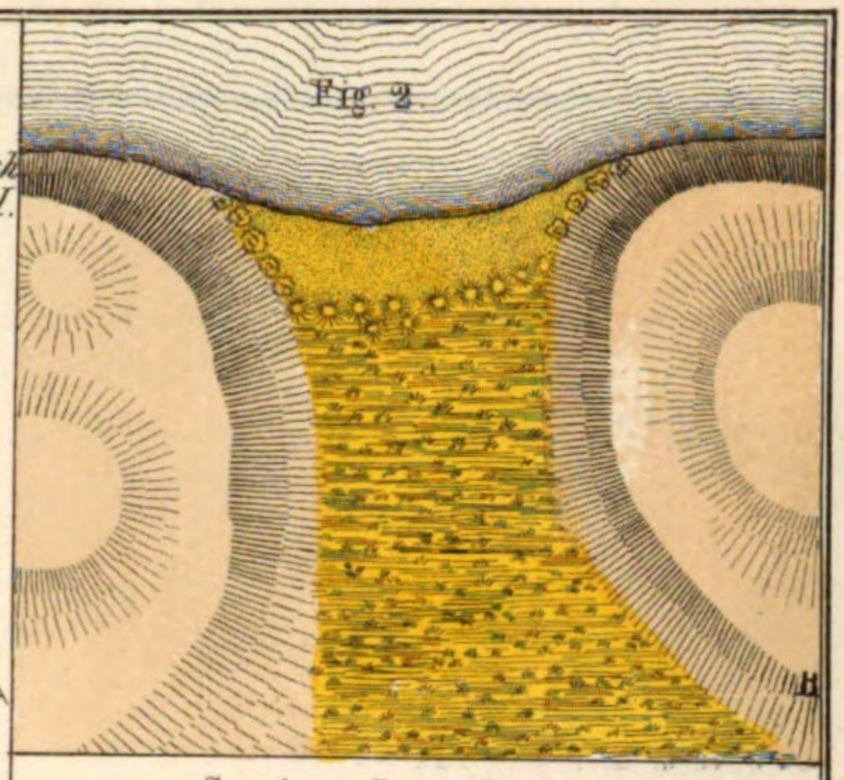
Fig 1.



Section *of a gravel bank, 1 mile on the road from Columbia ville to Hudson.*

Topographical Sketch *of the beach marsh &c 1 mile E. of Southold L I.*

Fig 2



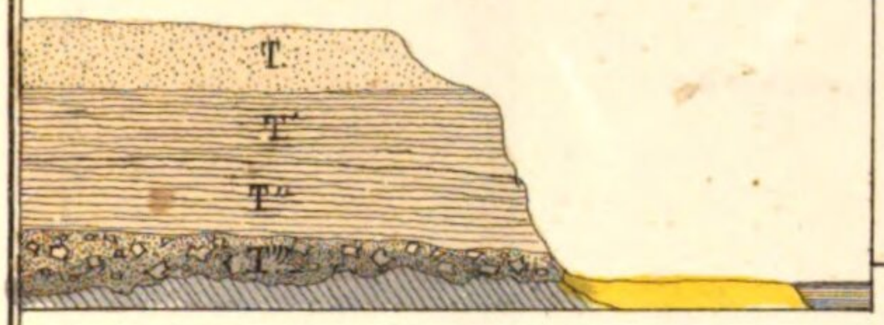
Section *along AB: above.*

Fig. 3.



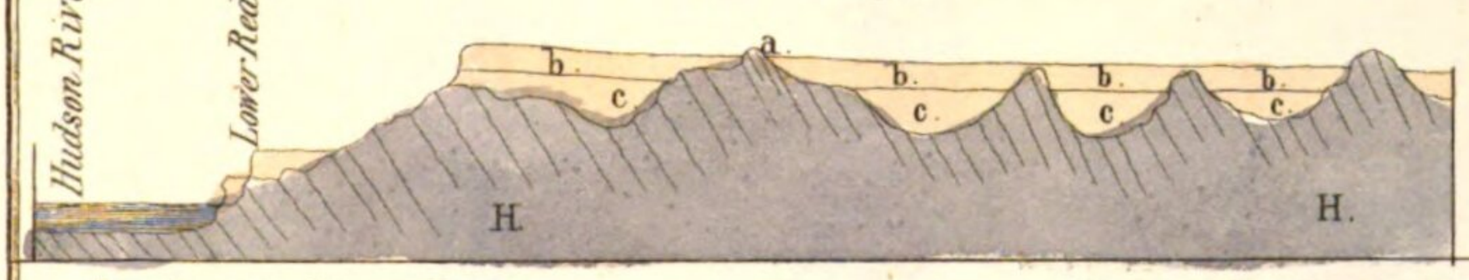
Section *on the West side of Newburgh Bay.*

Fig. 4.



Section *from Lower Red-Hook Landing E. 2 miles.*

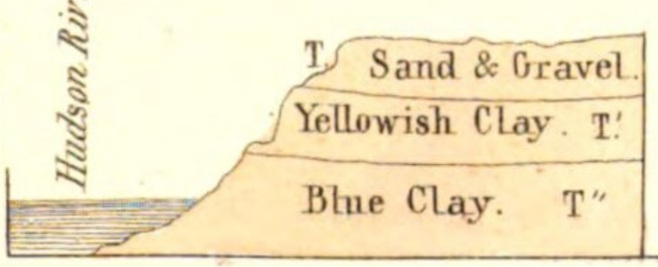
Fig. 5.



a. Sandy Loam.
b. Yellowish Clay Cont'g Clay Stones.
c. Blue Clay.
d. Hudson Slates & Grits.

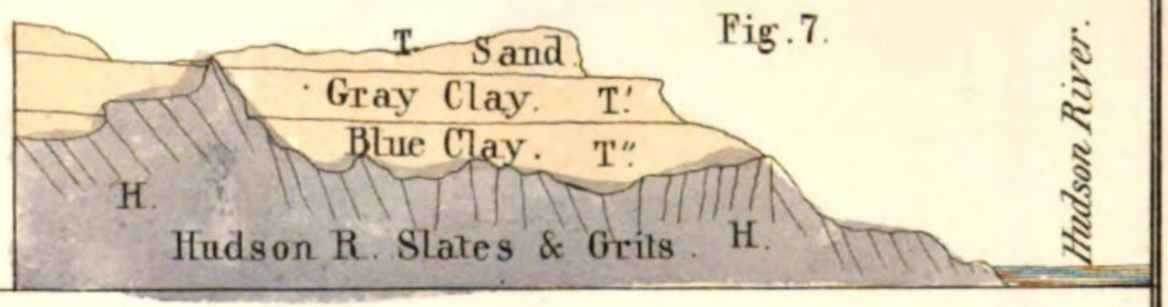
Section *at Grassy Point.*

Fig. 6.



Section *between the Hudson & Normanskill Albany County.*

Fig. 7.



Sections *in Hurley Ulster County.*

Fig. 8.

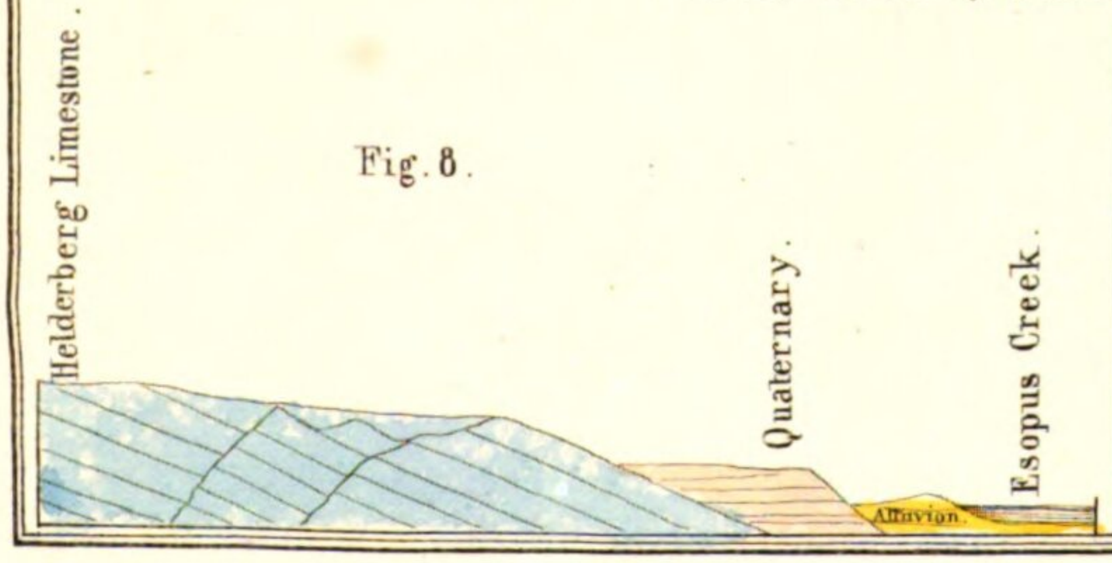
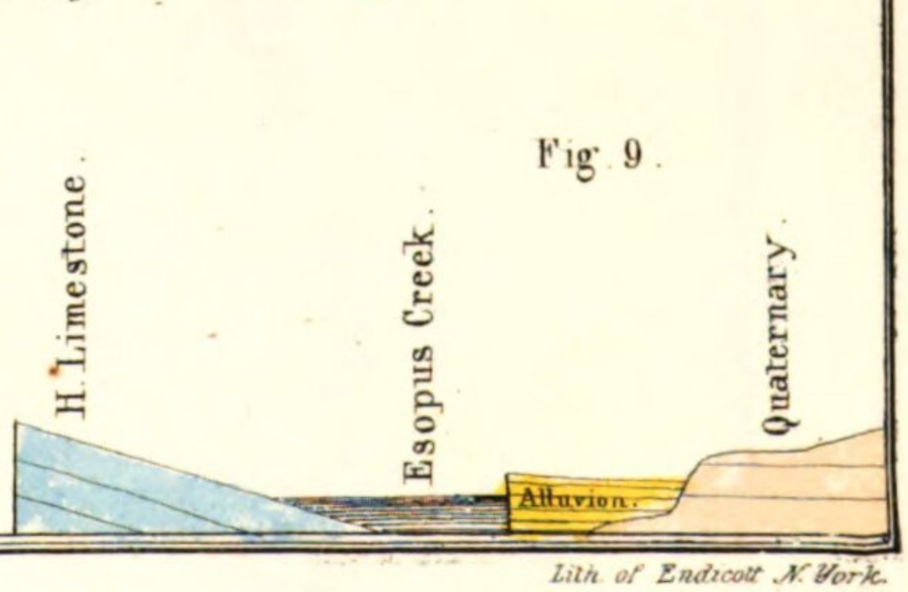


Fig. 9.



Lith of Endicott N. York.

Section *from Lake George by Whitehall to E. Poultney in Vt.*

Fig. 1.

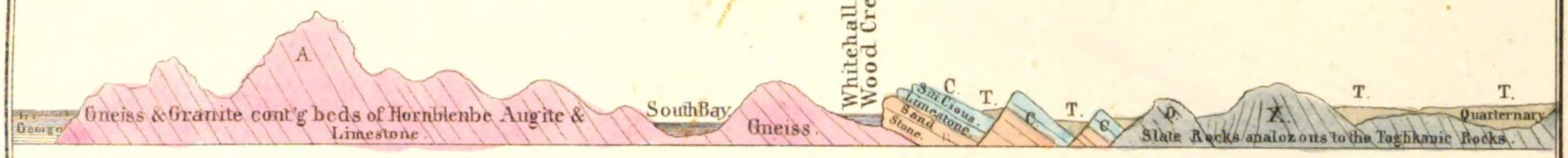
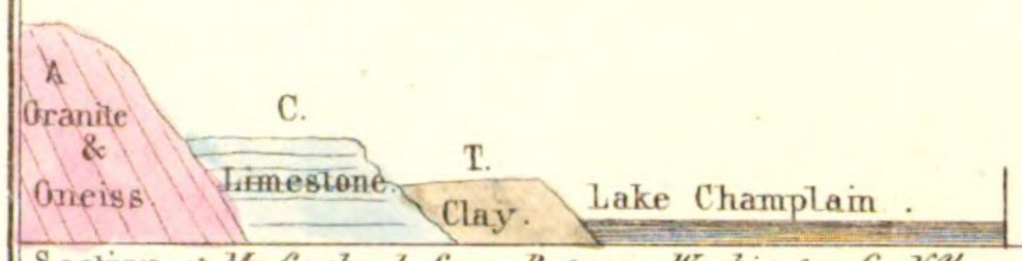


Fig 2.



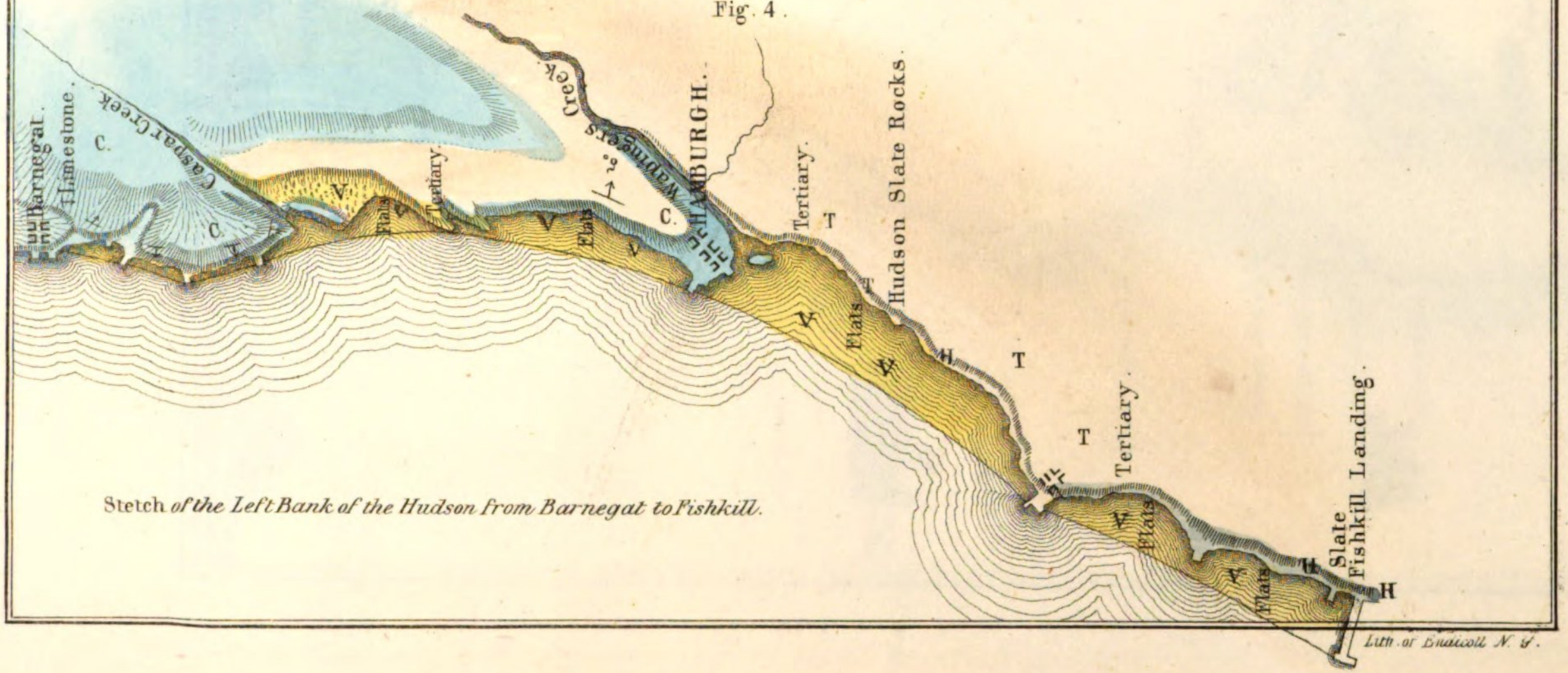
Section *at Mr. Goulards farm Putnam Washington Co. N.Y.*

Fig. 3.



Section *across 12 mile marsh Lake Champlain.*

Fig. 4.



Stetch *of the Left Bank of the Hudson from Barnegat to Fishkill.*

Fig. 1.

Oak Hill Ferry to Catskill
N. Line of Livingston.
Clay Hills.
Tertiary.
Crofts.
Contorted Slate.
C. & C. S. alternating. Oblique Clevage. Veins.
Strata S. row.
N. Line of Germantown.
Rock.
Clay.
Clay.
Clay.
Clay.
Confortion
S. Line of Germantown.
BRISTOL.
Arched Strata.
Y.
LIGHT HS.
BARRYTOWN.
Kaal
Saghkill.
Kaal
Lower Red Hook Landing.

Fig. 2.

Garrisons Pt
Kingston Landing
RHINEBECK.
Contorted S.
RONDOUT
Contorted Strata.
Contorted Strata.
Thomsons Landing.
HUDSON RIVER.
Lewis Landing
Remarkable locality.
Arched.
Grit & Slate with Quartz Veins.
Hyde Park.

Fig. 3.

Section
in Sullivan Co. Catskill Mt. rocks.

Lith. of G. Endicott. N. York.

Contorted Limestone *with zigzag & wrinkled laminae on the E. Shore of Peckskill Bay.*

Fig. 1.

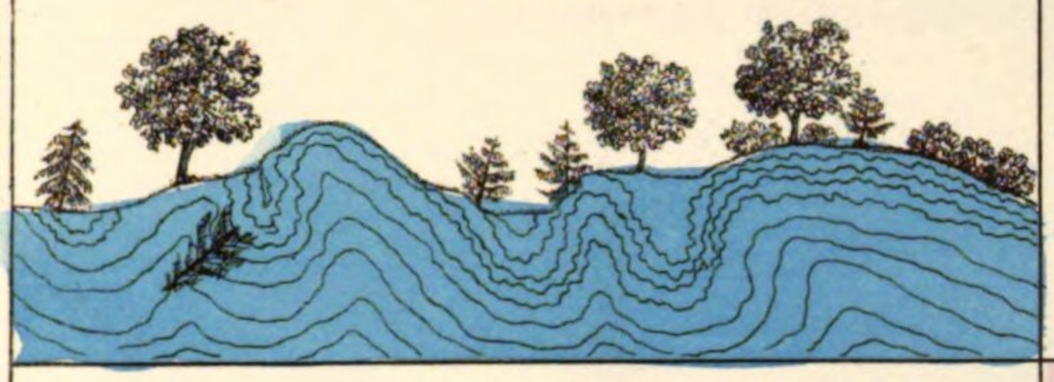
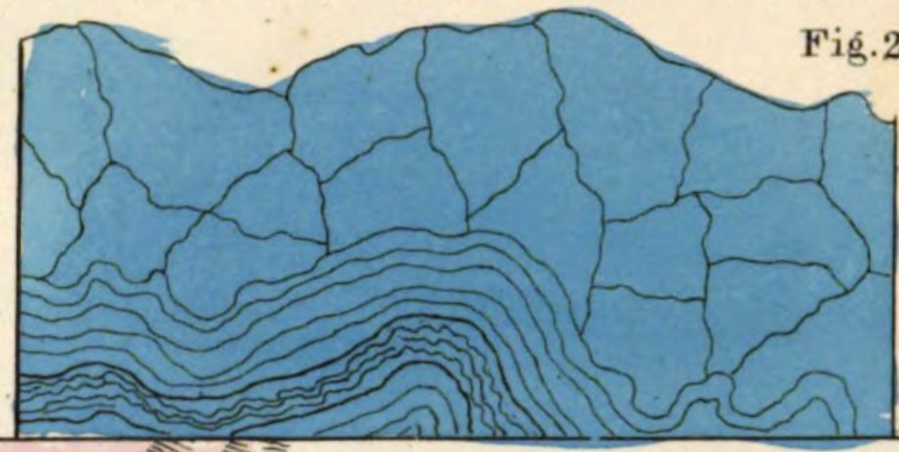
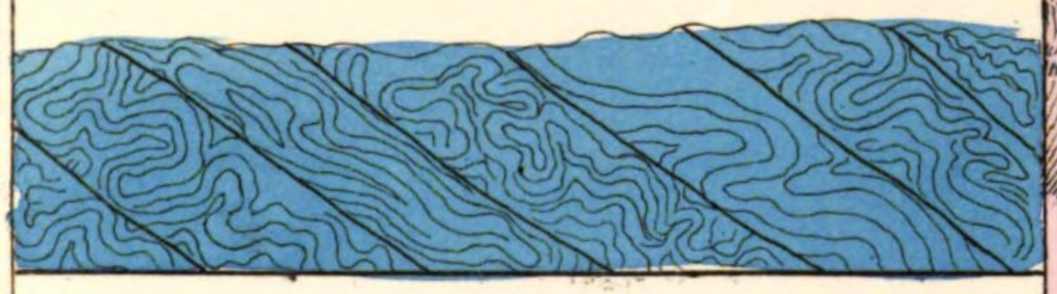


Fig. 2.



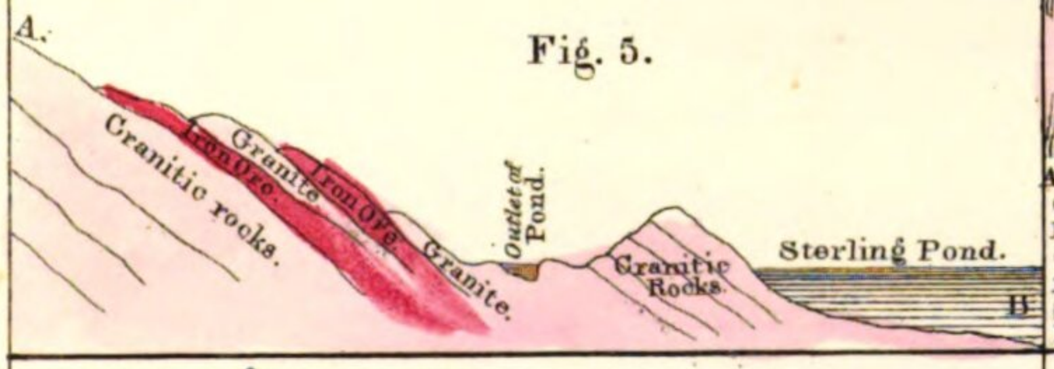
Plane strata of Limestone *with wrinkled laminae.*

Fig. 3.



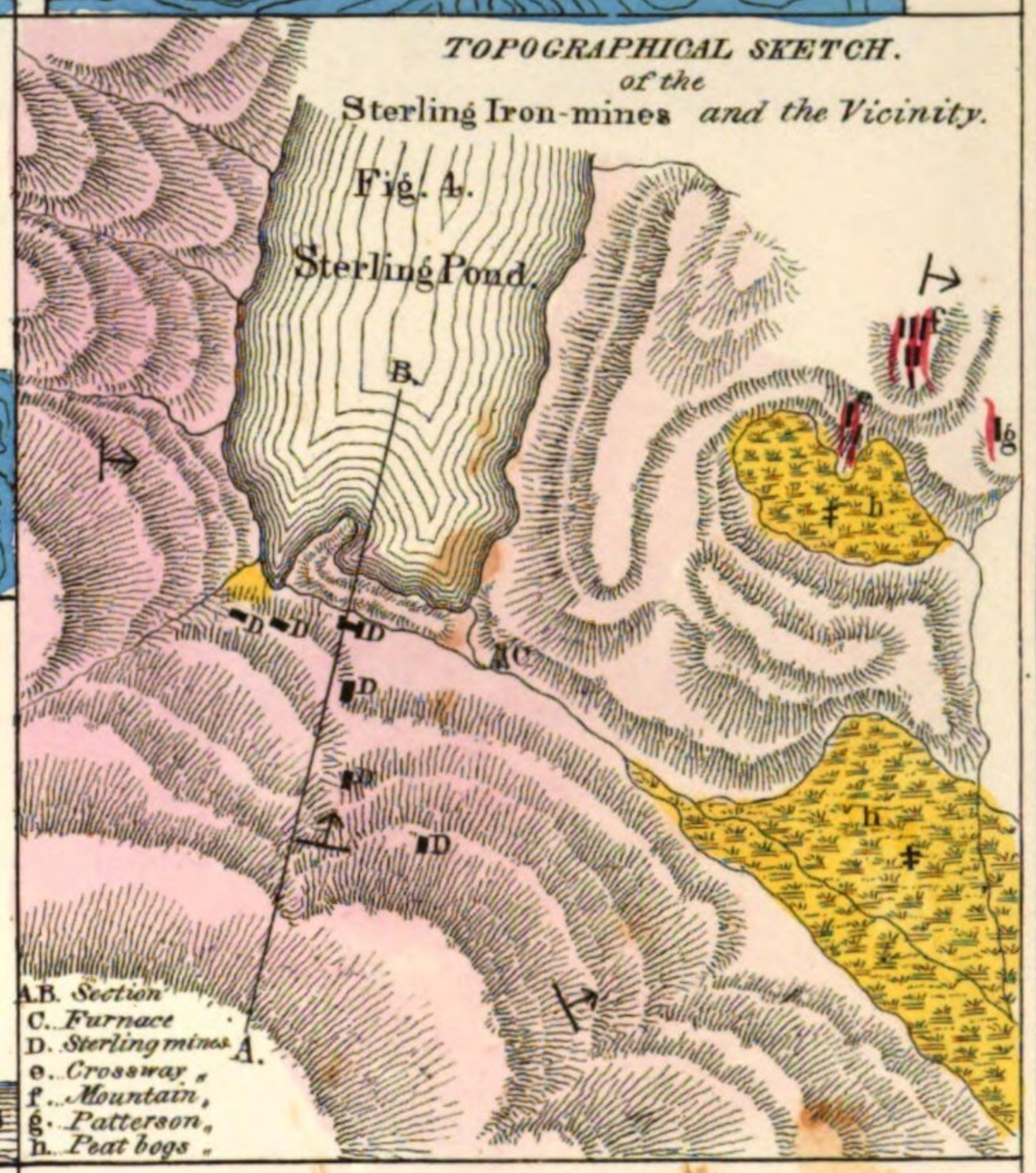
Section *along* A.B *of Fig. 4.*

Fig. 5.



TOPOGRAPHICAL SKETCH.
of the
Sterling Iron-mines *and the Vicinity.*

Fig. 4.

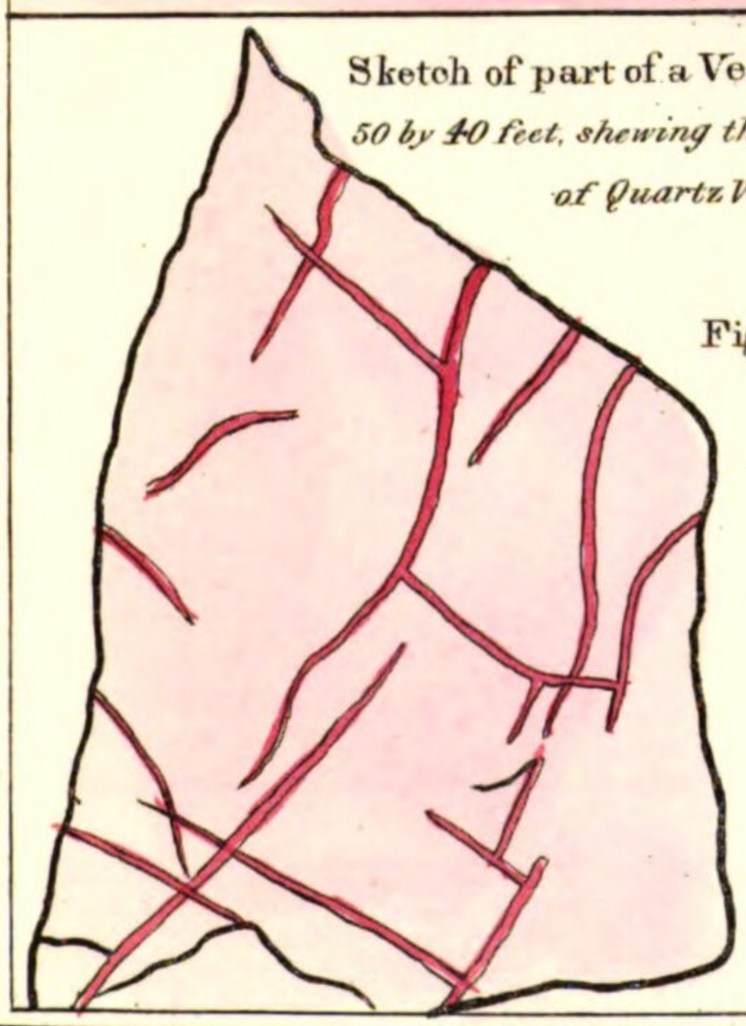


Sketch of part of a Vein of Granite.

50 by 40 feet, shewing the arrangement of Quartz Veins.

by L.D.Gate.

Fig. 6.

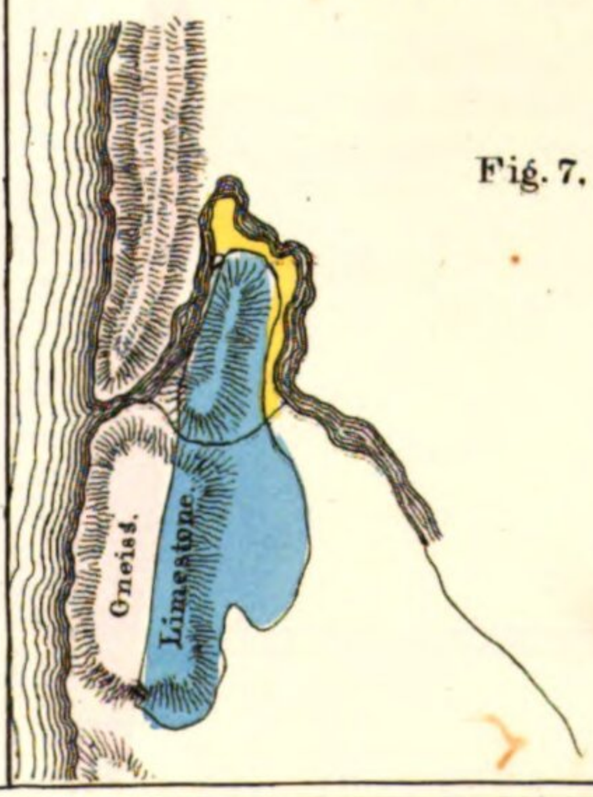


Sketch *illustrating the extent of the* Primary Limestone.

on the N. end of New-York Island.

by L. D. Gale.

Fig. 7.



Lith. of C. Endicott N. York.

Sections
near the Gravel pits, Patroons Creek Albany.
by Ja.s Eights.

Fig. 1.

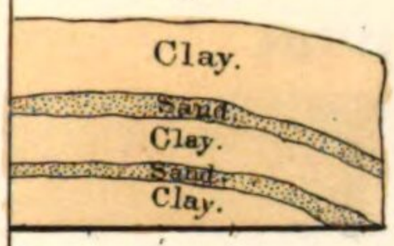


Fig 2.

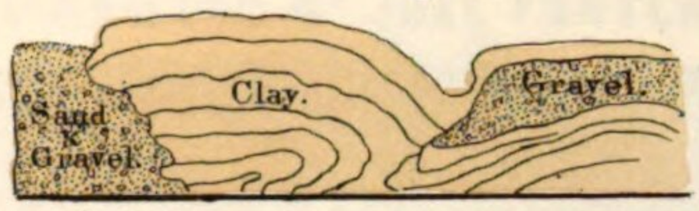
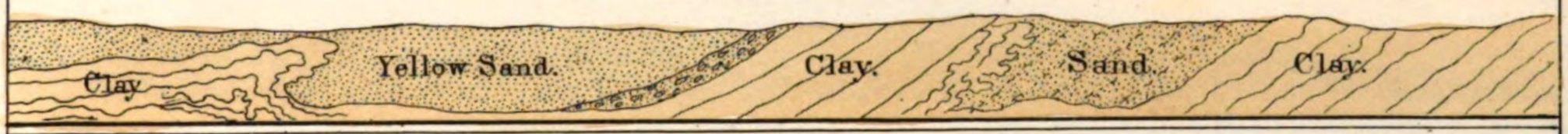


Fig. 3.



Section *of*
the Clay & Sand beds. Arbor Hill Albany.
Effects of Slips.
by Ja.s Eights.

Fig. 4.



Fault & wrinkles in the Clay-beds.
caused by Slips, West of the Medical College Albany.

Fig. 5.

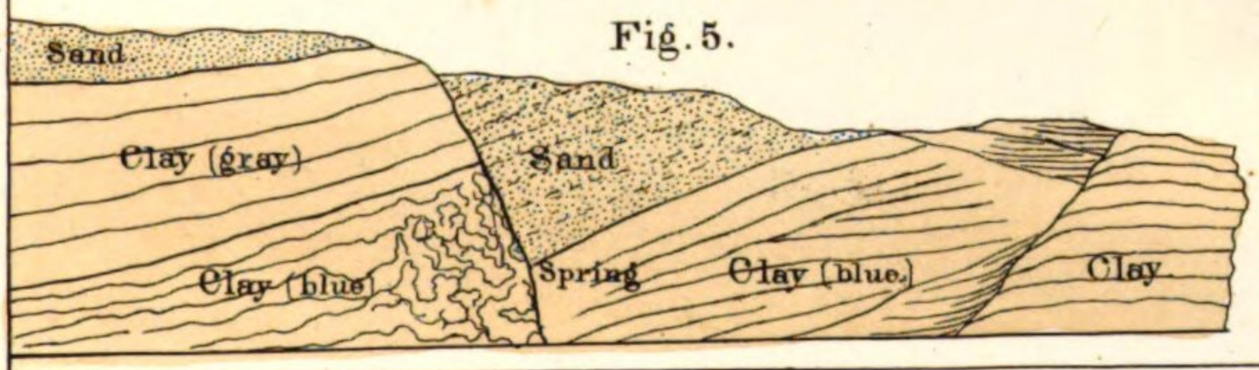


Fig. 6.

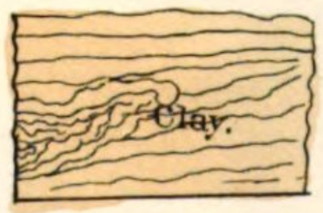
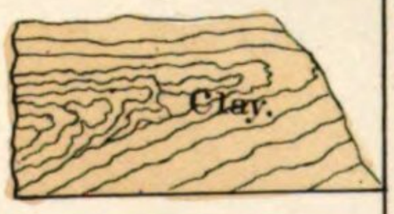
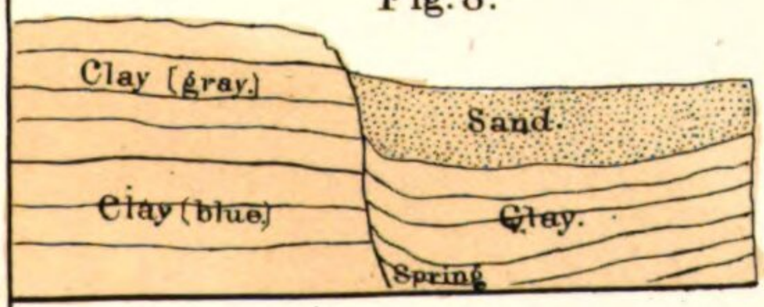


Fig. 7.



Fault in the Clay beds,
West of the Medical College Albany.

Fig. 8.





Section
shewing the actual thickness of the layers & the shades of Colour in blue Clay, Albany.
by Ja.s Eights.

Fig. 9.

Lith. of G. Endicott, N. York

BALLS CAVE,

PLATE 32.

SCHOHARIE COURT HOUSE.

1st. from the Entrance to the Square Room or North end, is about half a Mile in length

was Explored by

JOHN GEBHARD ESQ^{R} & JOHN S. BONNY;

30th. May 1832:

2nd. From the Entrance to the Rotunda or South end,

Explored by:

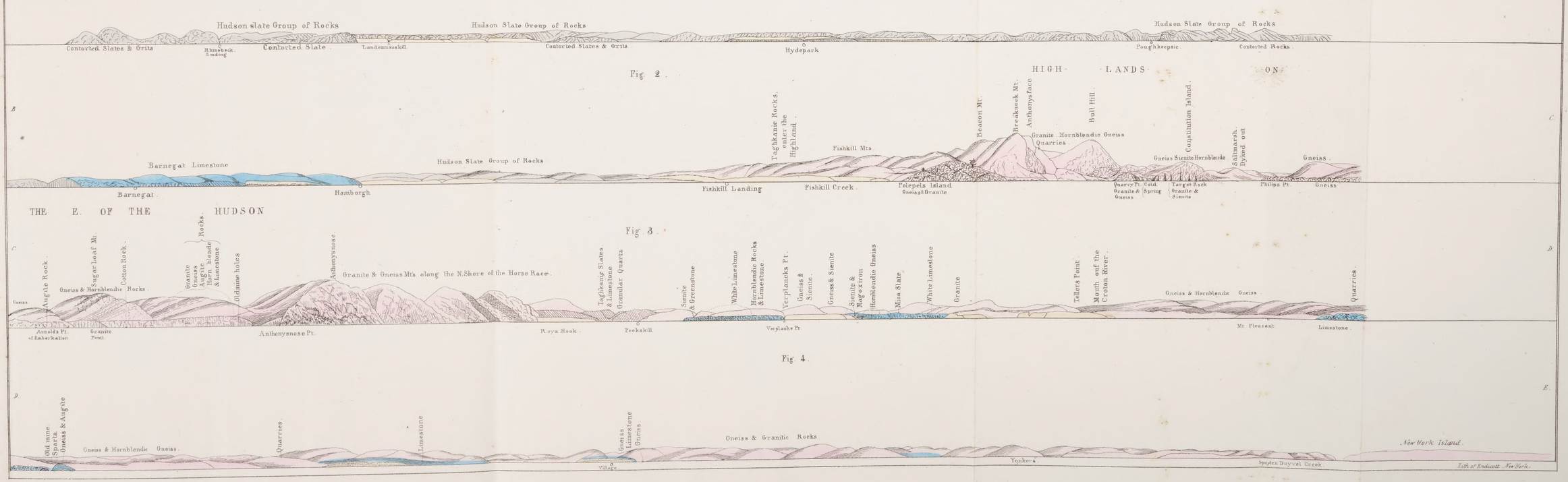
JOHN GEBHARD ESQ. D^{R} JOEL FOSTER, & JOHN S. BONNY:

21st. Oct. 1831.

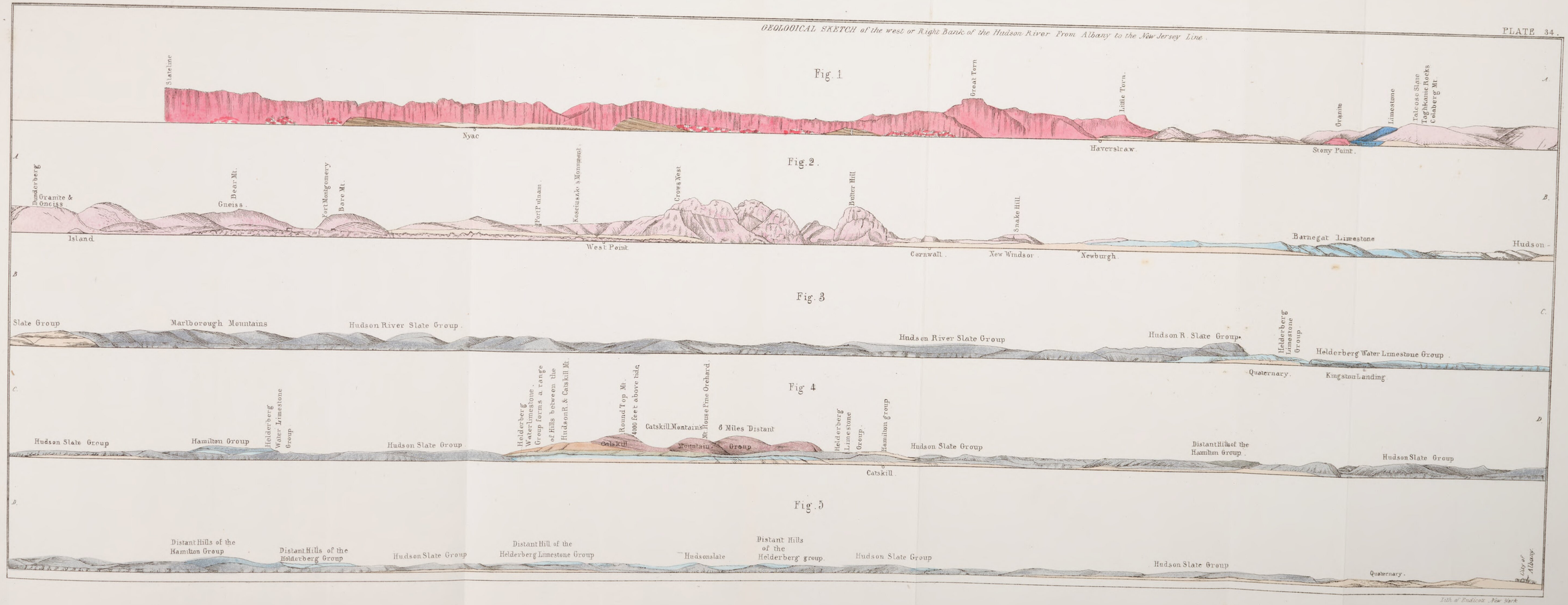
Lith. of Endicott N. York.

Fig 1.

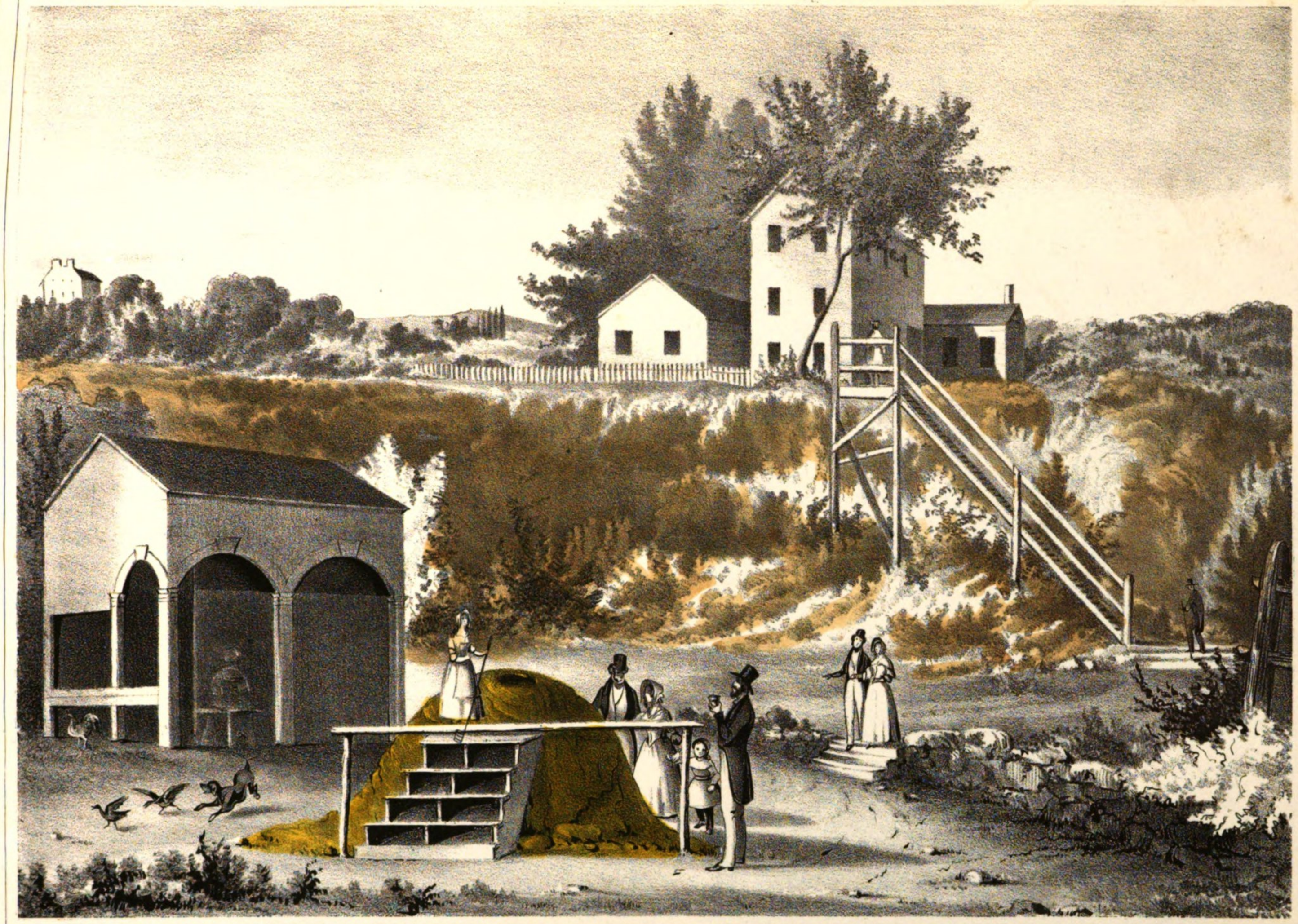
Geological Sketch from Rhinebeck to New-York Island on the left or East bank of the Hudson River.



GEOLOGICAL SKETCH of the west or Right Bank of the Hudson River From Albany to the New Jersey Line.



Lith. of Endicott, New York



LITH OF ENDICOTT NEWYORK.

HIGHROCK SPRING, SARATOGA N. YORK.

Fig. 1.

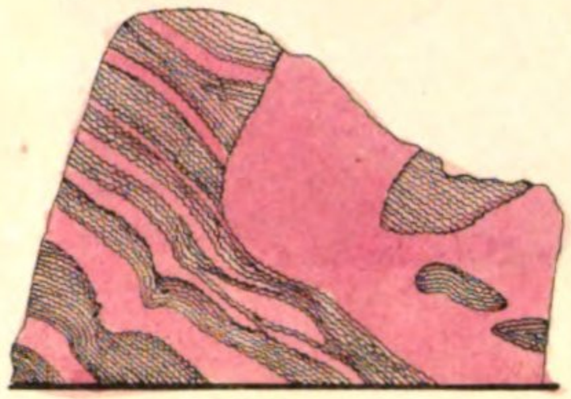


Fig. 2.

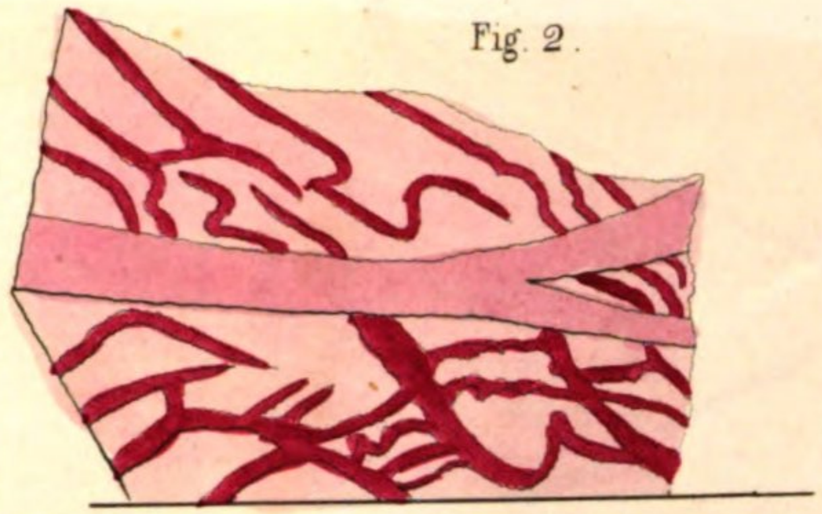


Fig. 3.

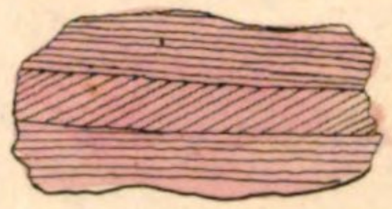


Fig. 4.

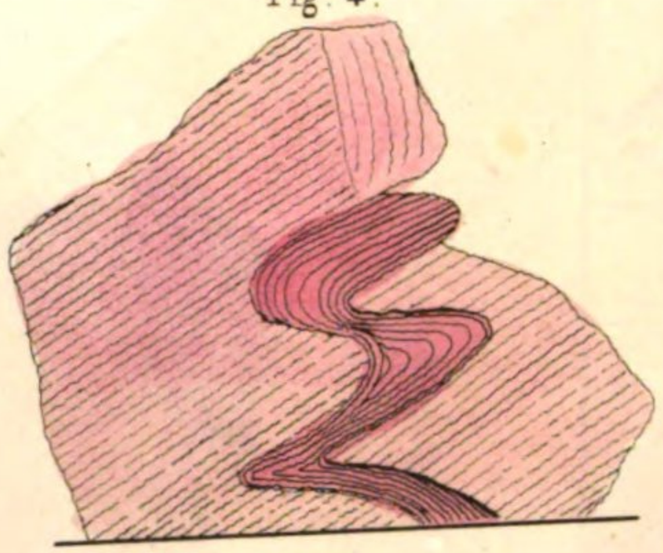
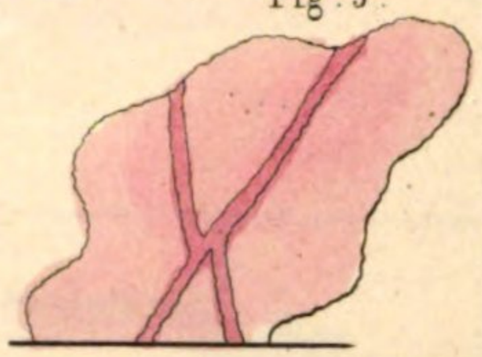
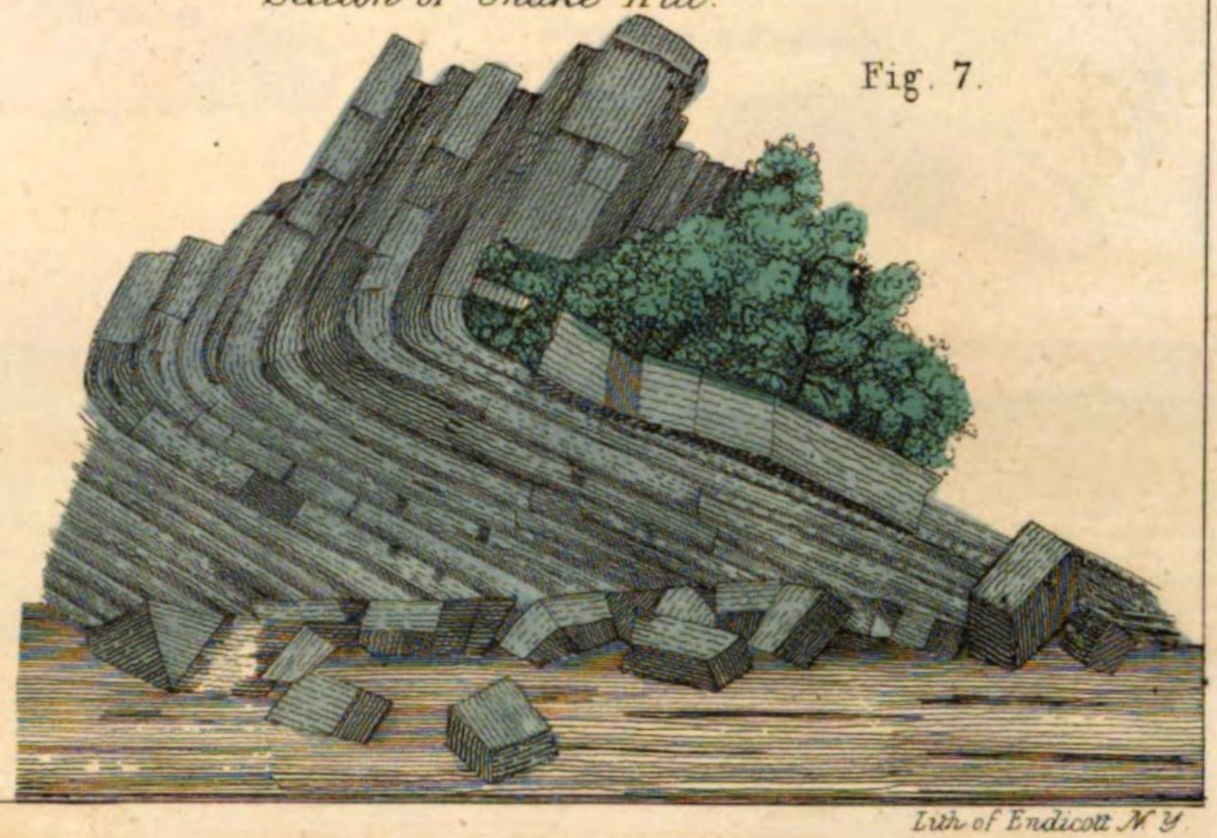


Fig. 5.



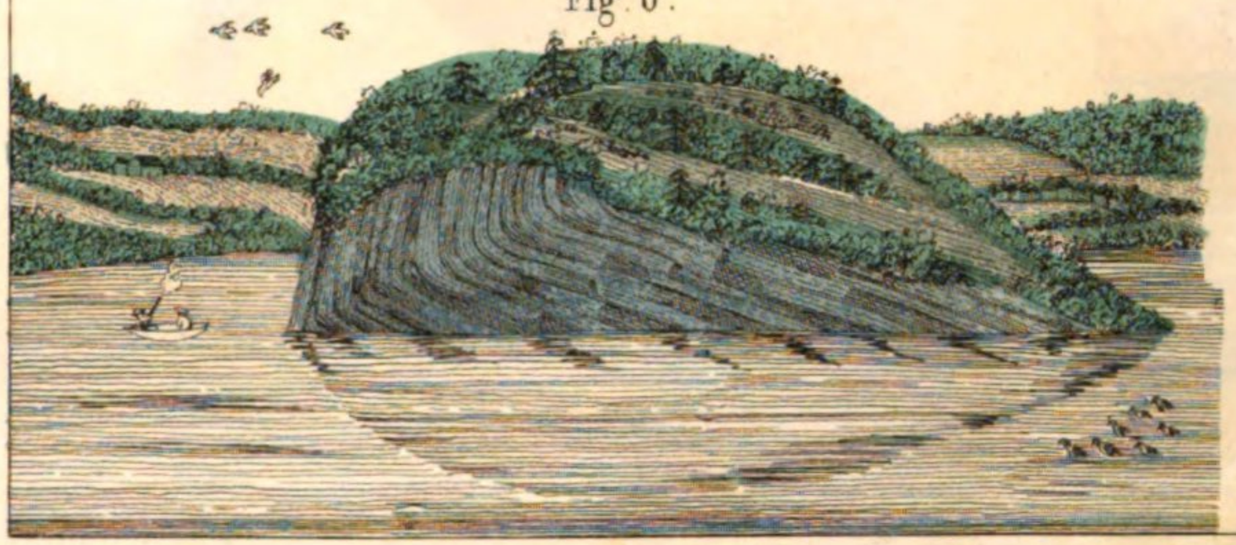
Section of Snake Hill.

Fig. 7.



Snake Hill in Saratoga Lake.

Fig. 6.



Lith. of Endicott N.Y.

Fig. 1.

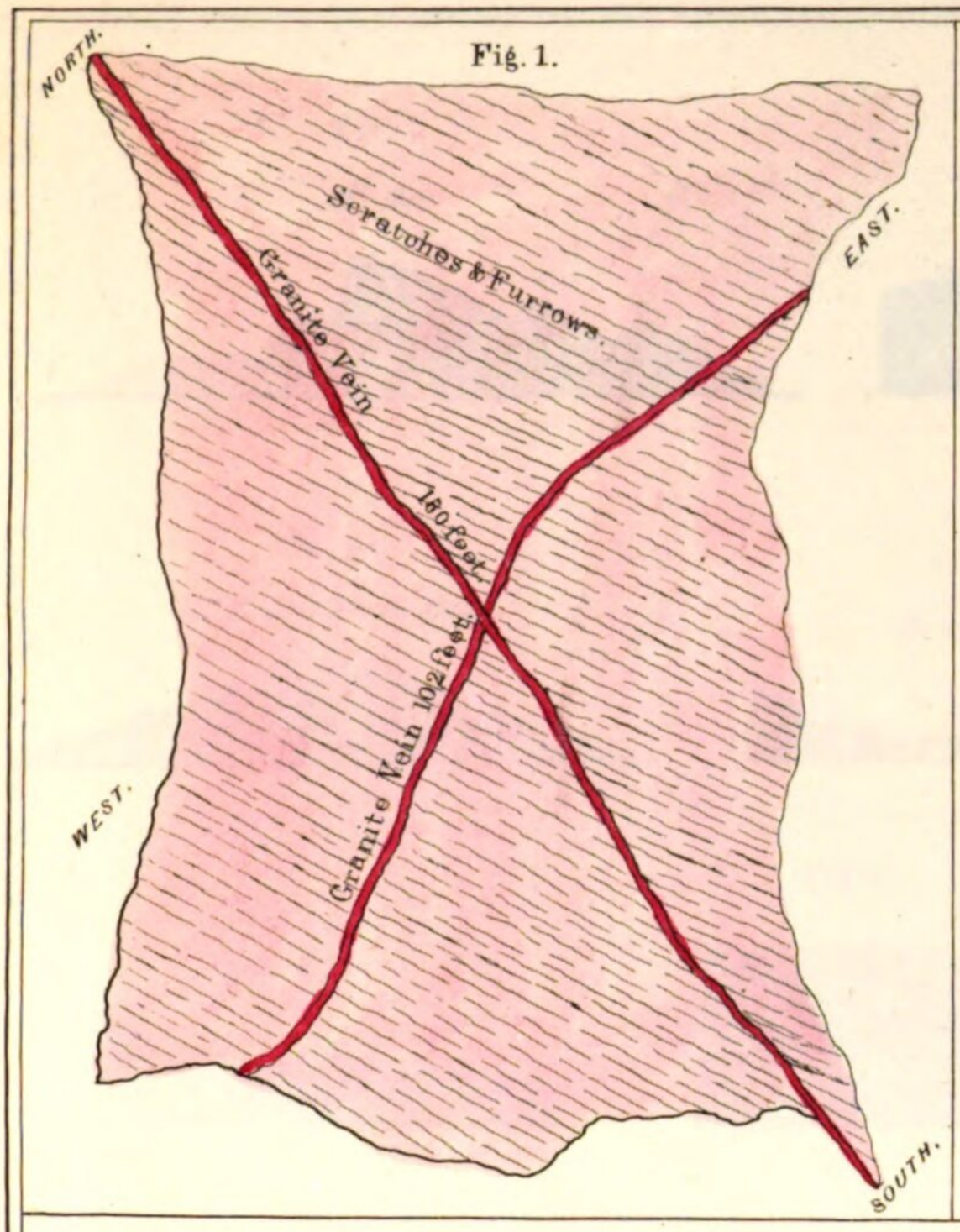


Fig. 2.

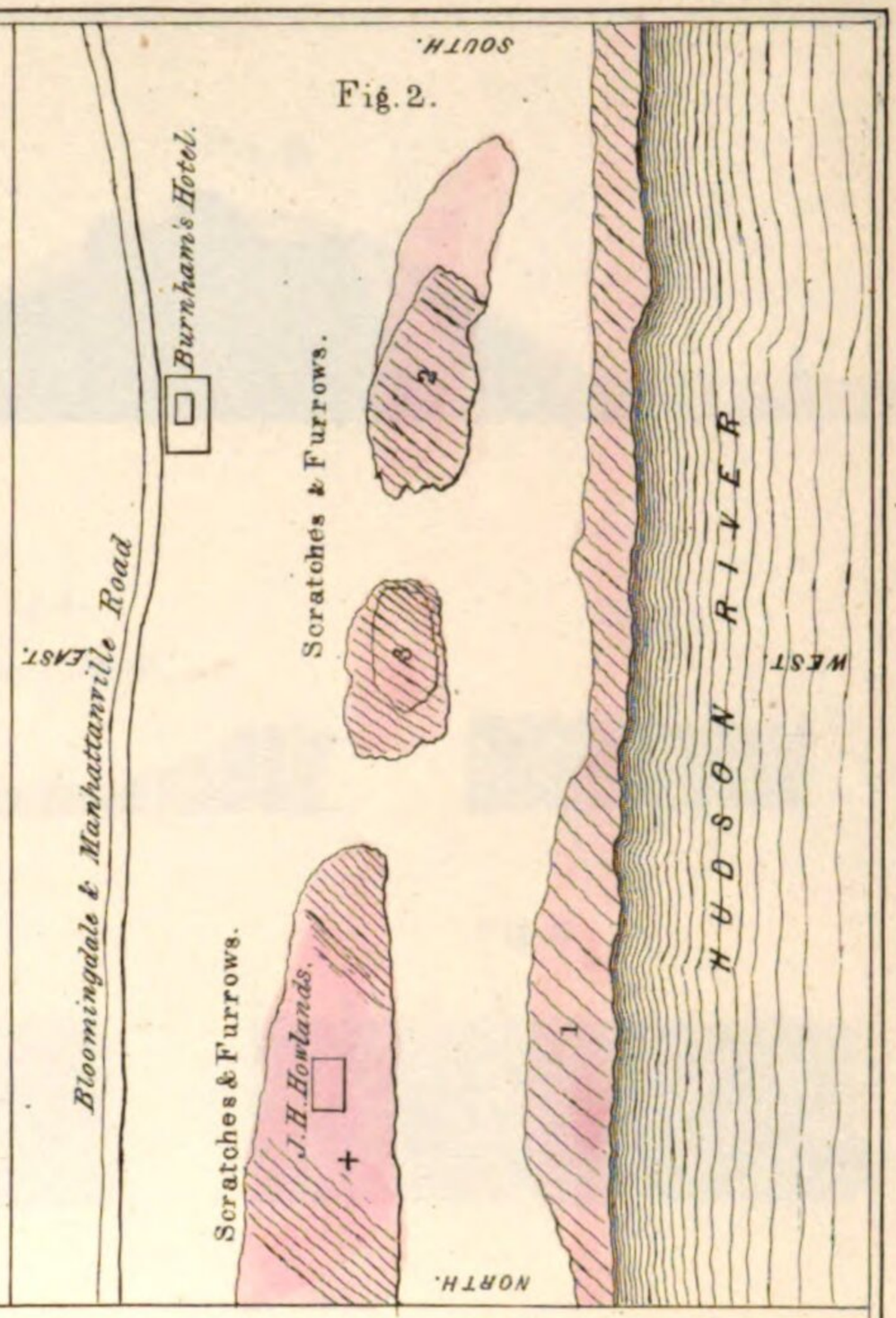


Fig. 3.

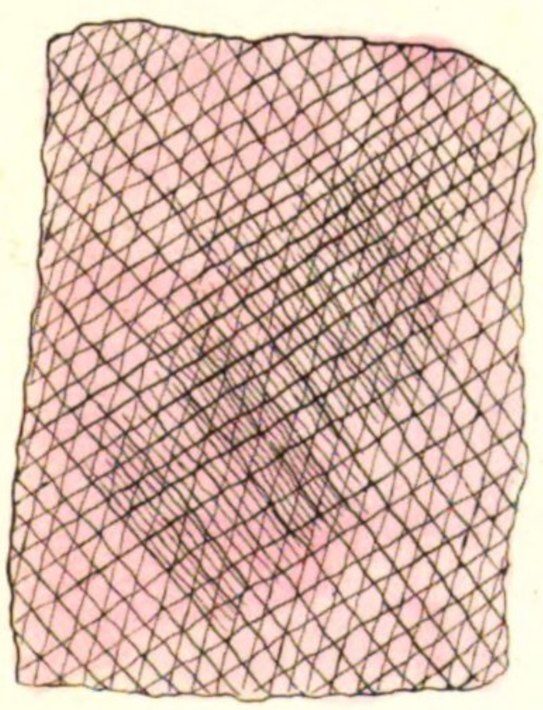
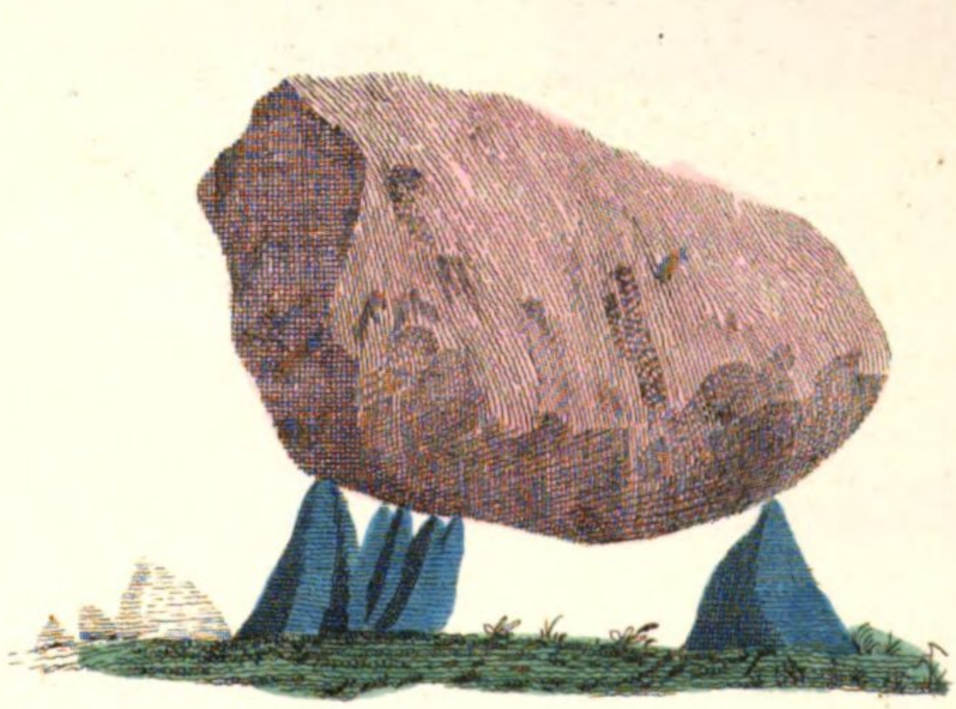


Fig. 4.



Lith. of Endicott N. York

Fig. 1.

Mt. Bob.

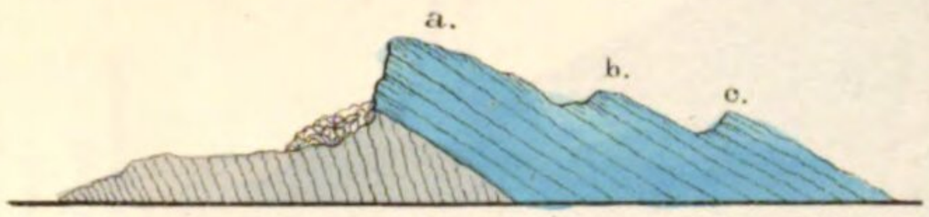


Fig. 2.

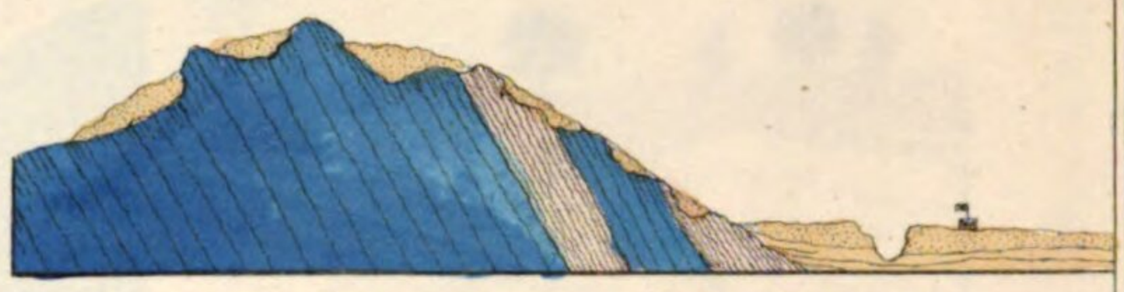


Fig. 3.

N. End of Nutten Hook.



Fig 4.

Riders Mills.



Fig. 5.



Fig. 6.



Fig. 7.



Fig. 8.

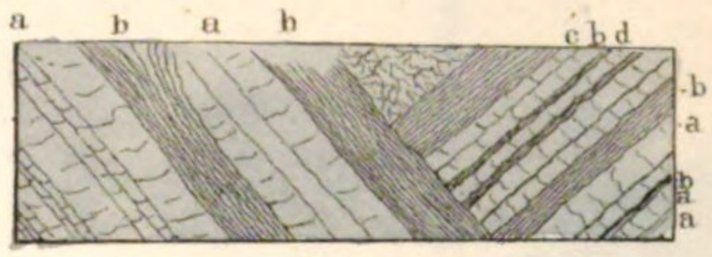


Fig. 9.

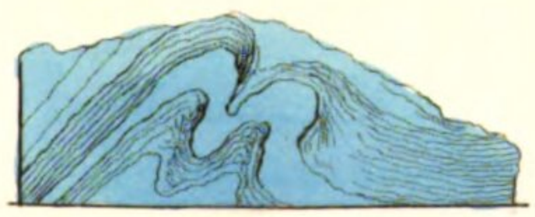


Fig. 10.

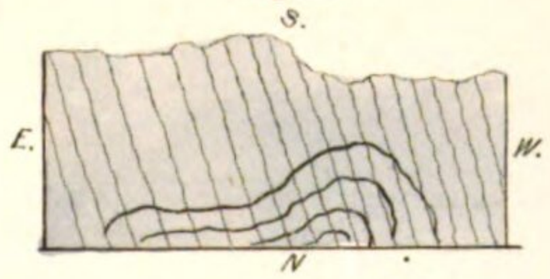


Fig 11.



Fig. 12.

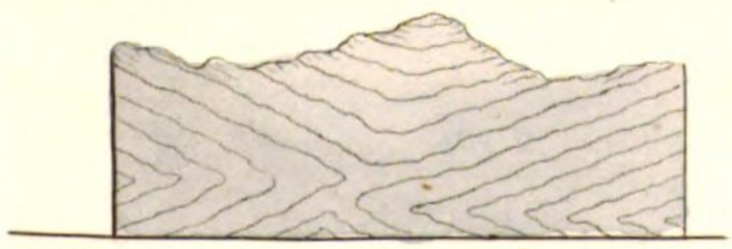


Fig 13.

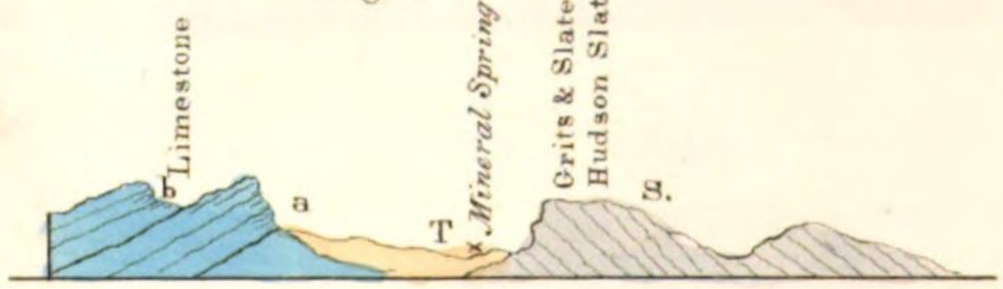
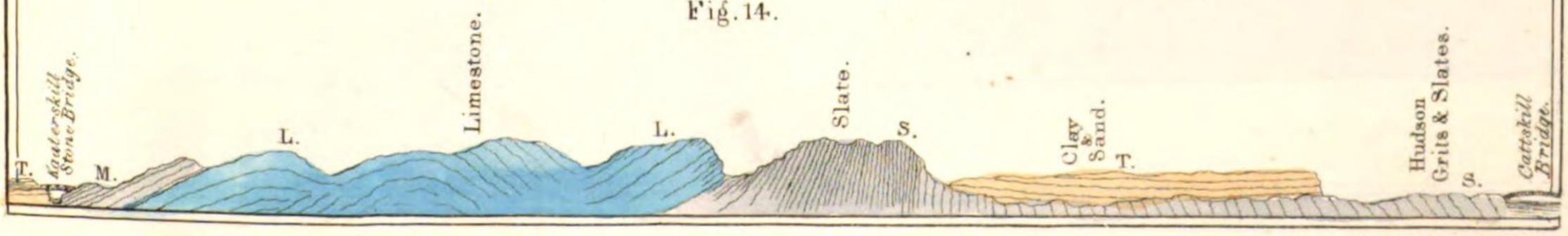


Fig. 14.



Lith. of Endicott N York.

Fig. 1.

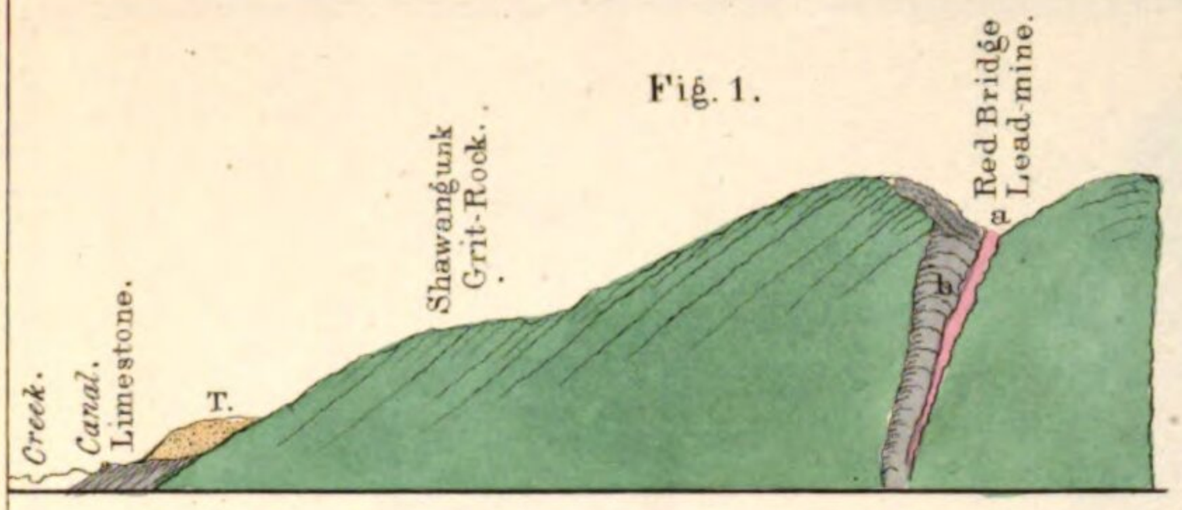


Fig. 4.



Fig. 2.

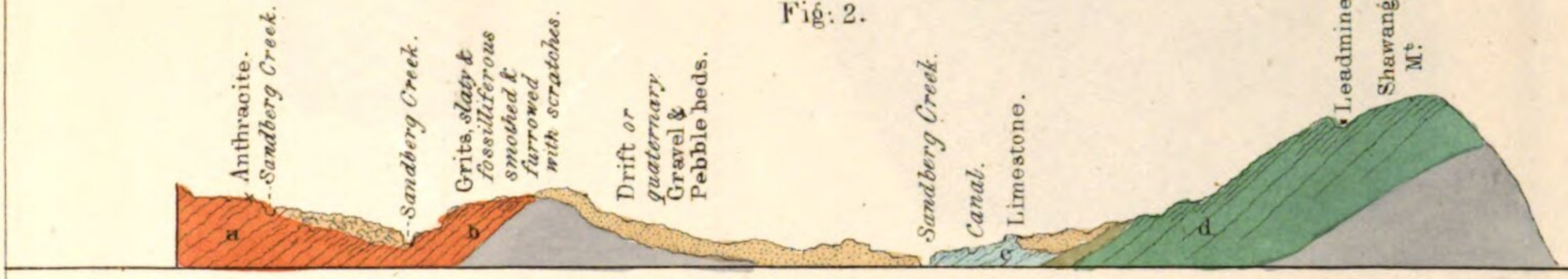


Fig. 3.

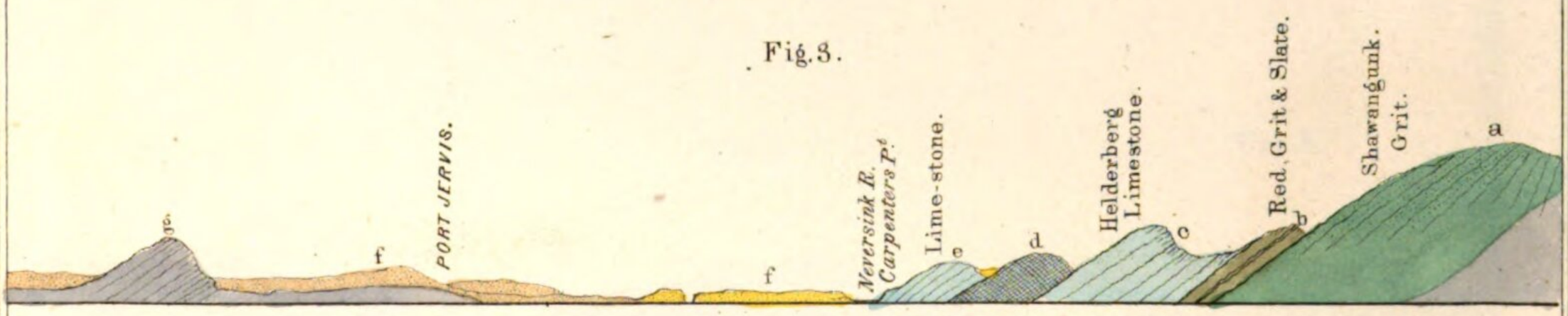


Fig. 5.

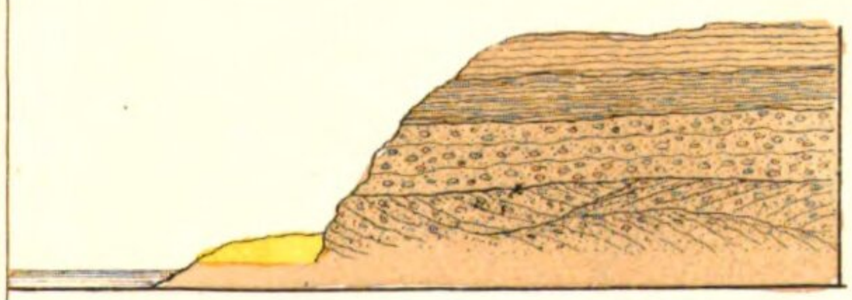


Fig. 6.

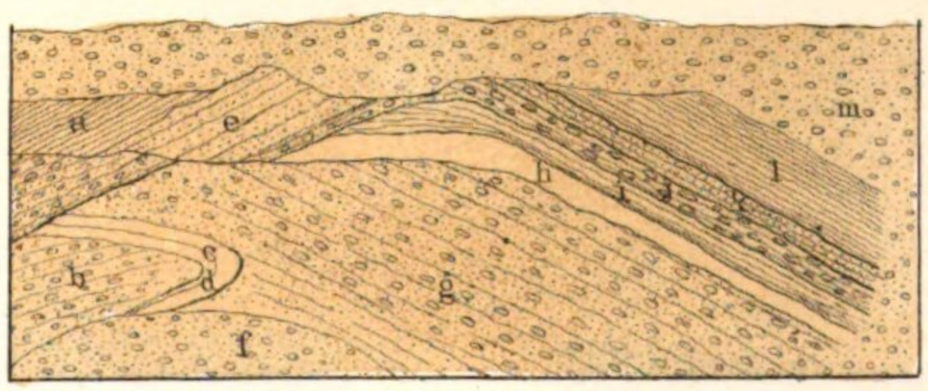


Fig. 7.

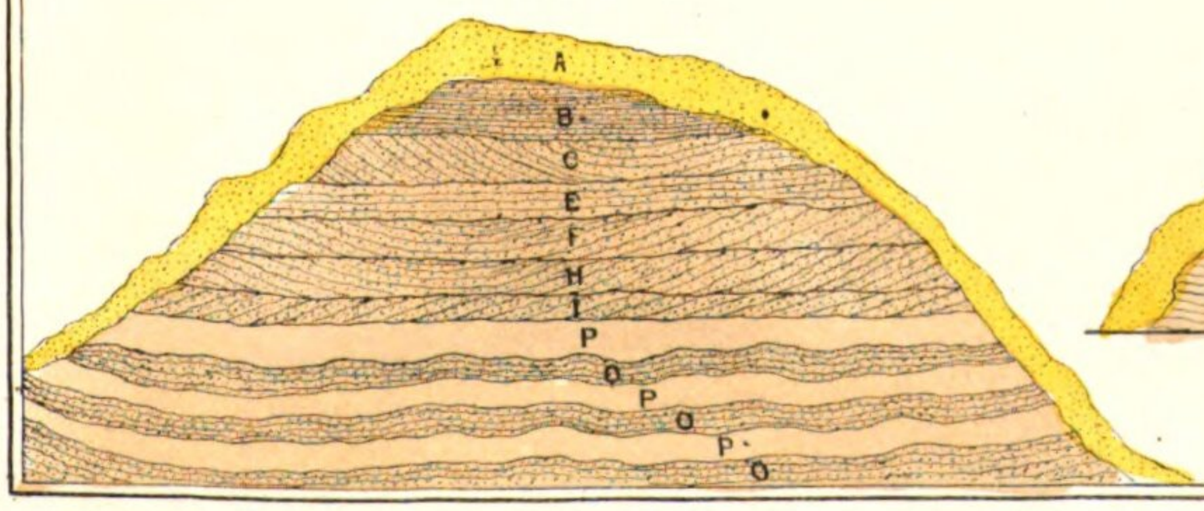
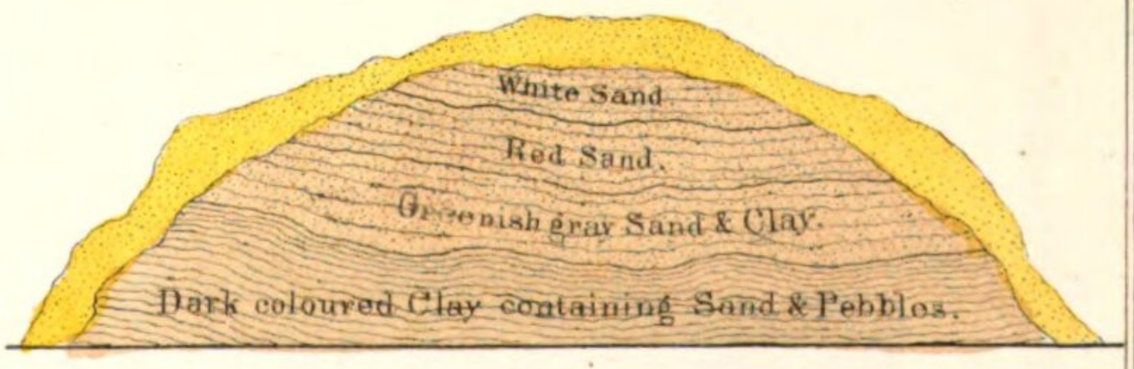


Fig. 8.



Lith. of Endicott N York

Fig. 1.

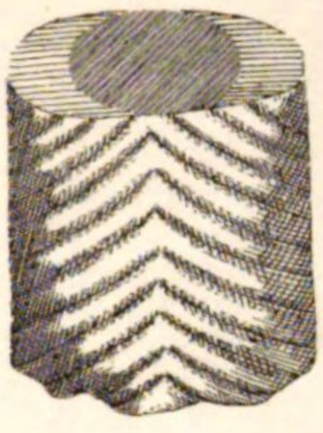
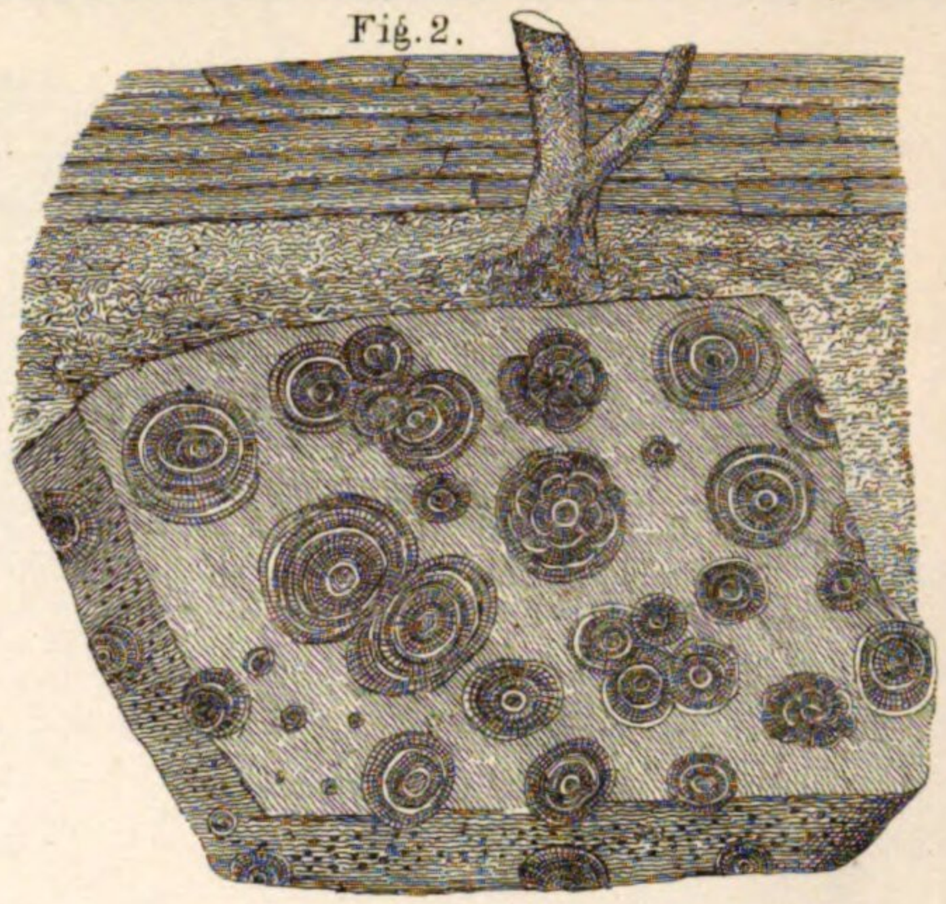
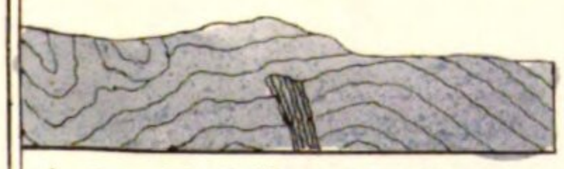


Fig. 2.



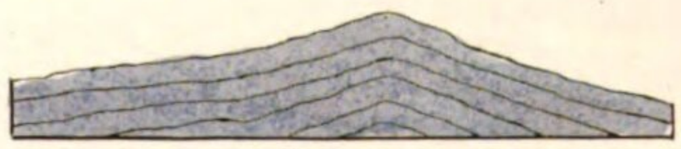
Oolitic structure.

Fig. 3.



2 m. E. of Alexander's Bridge.

Fig. 4.



50 rods above Alexander's Aquaduct.

Fig. 5.

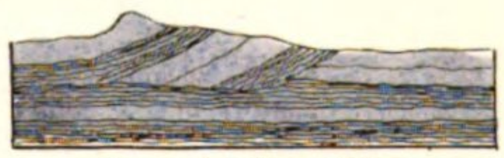


Below the Aquaduct.

Fig. 6.



Fig. 7.



2 m. W. of Half Moon.

Fig. 8.



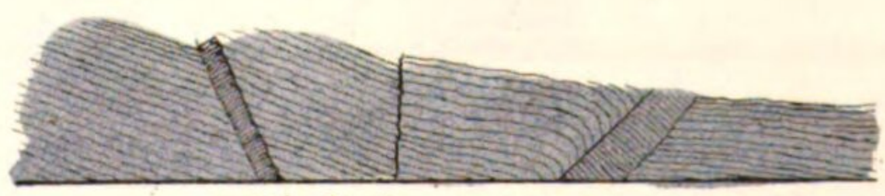
3 m. W. of Vischer's quarry.

Fig. 9.



½ m. E. of Vischer's quarry.

Fig. 10.



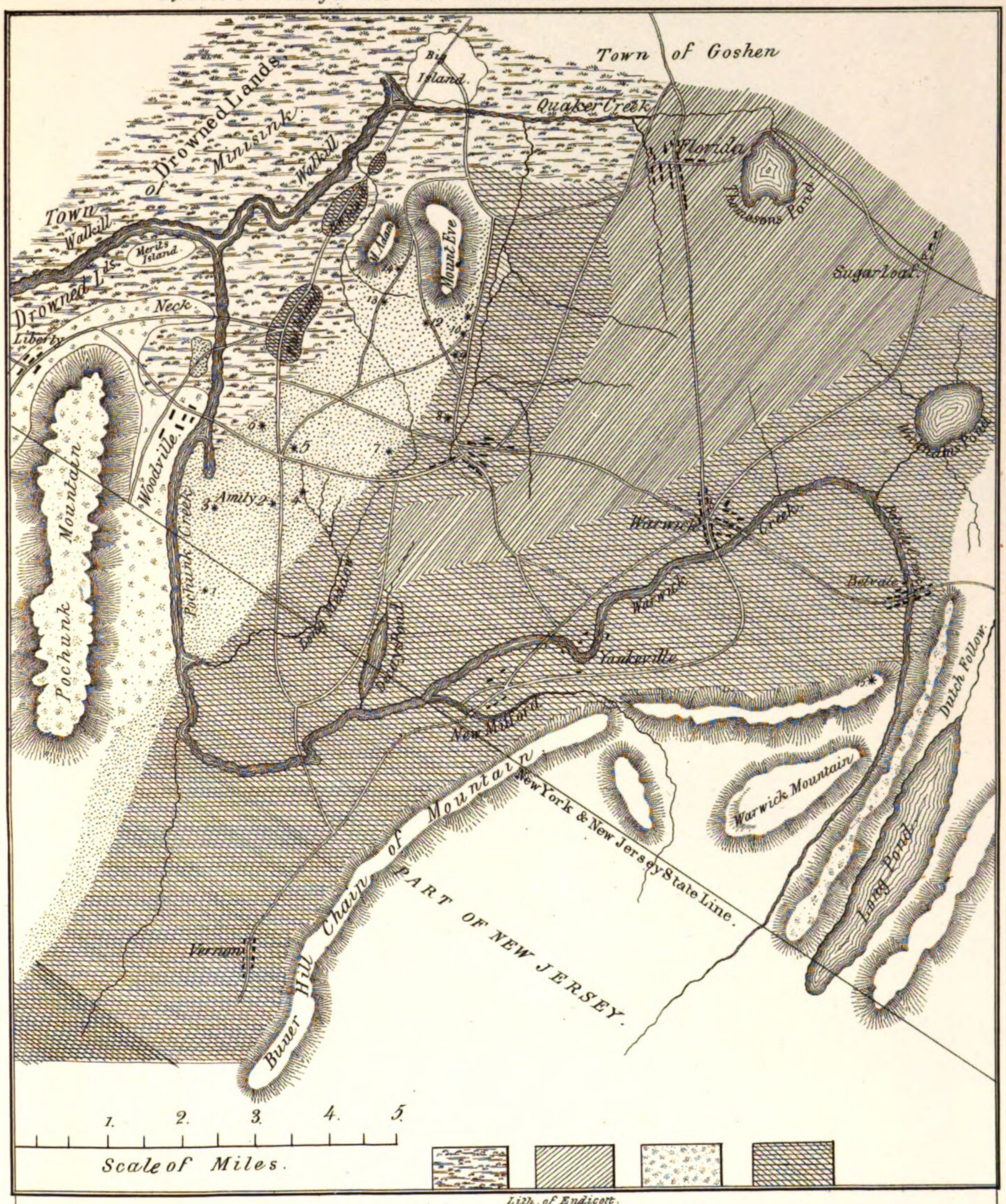
Vischer's quarry.

Lith. of Endicott, N. York.

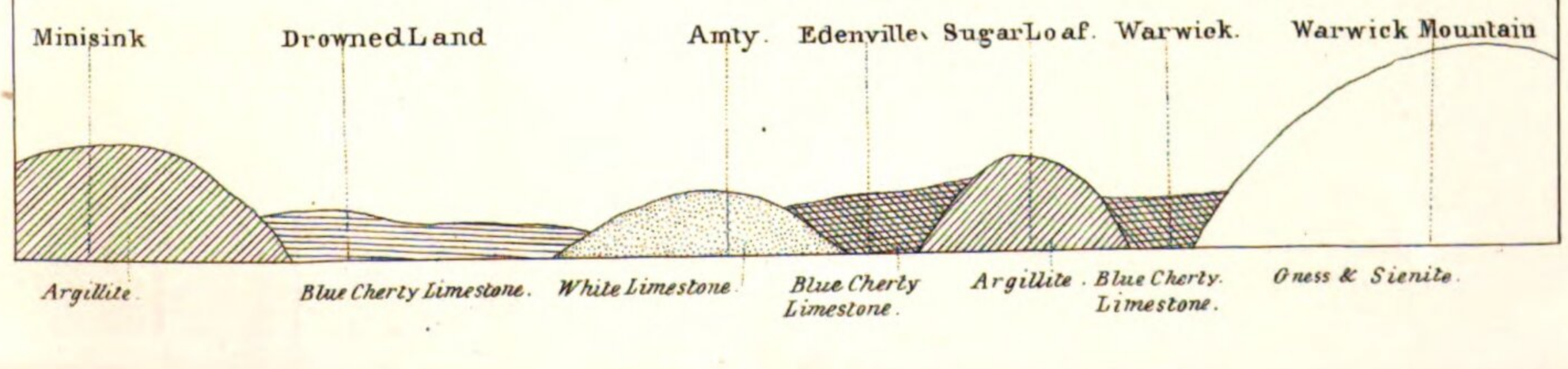
PLATE 41.

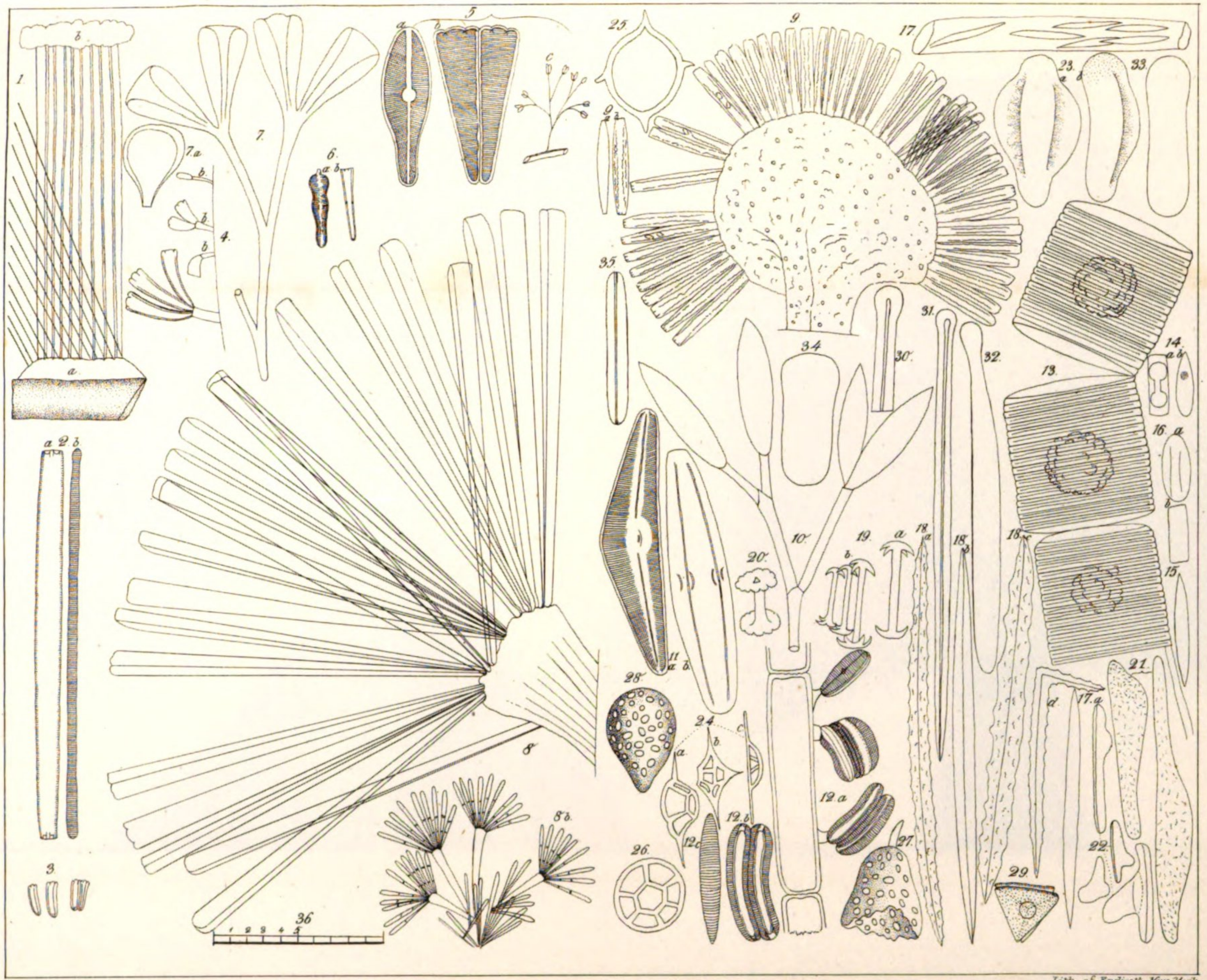
Geological and Mineralogical MAP of a part of Orange County N. YORK.

By Doct. J. P. Young of Edenville & Doct. J. Heron of Warwick Jun 10th 1831.



Lith. of Endicott.

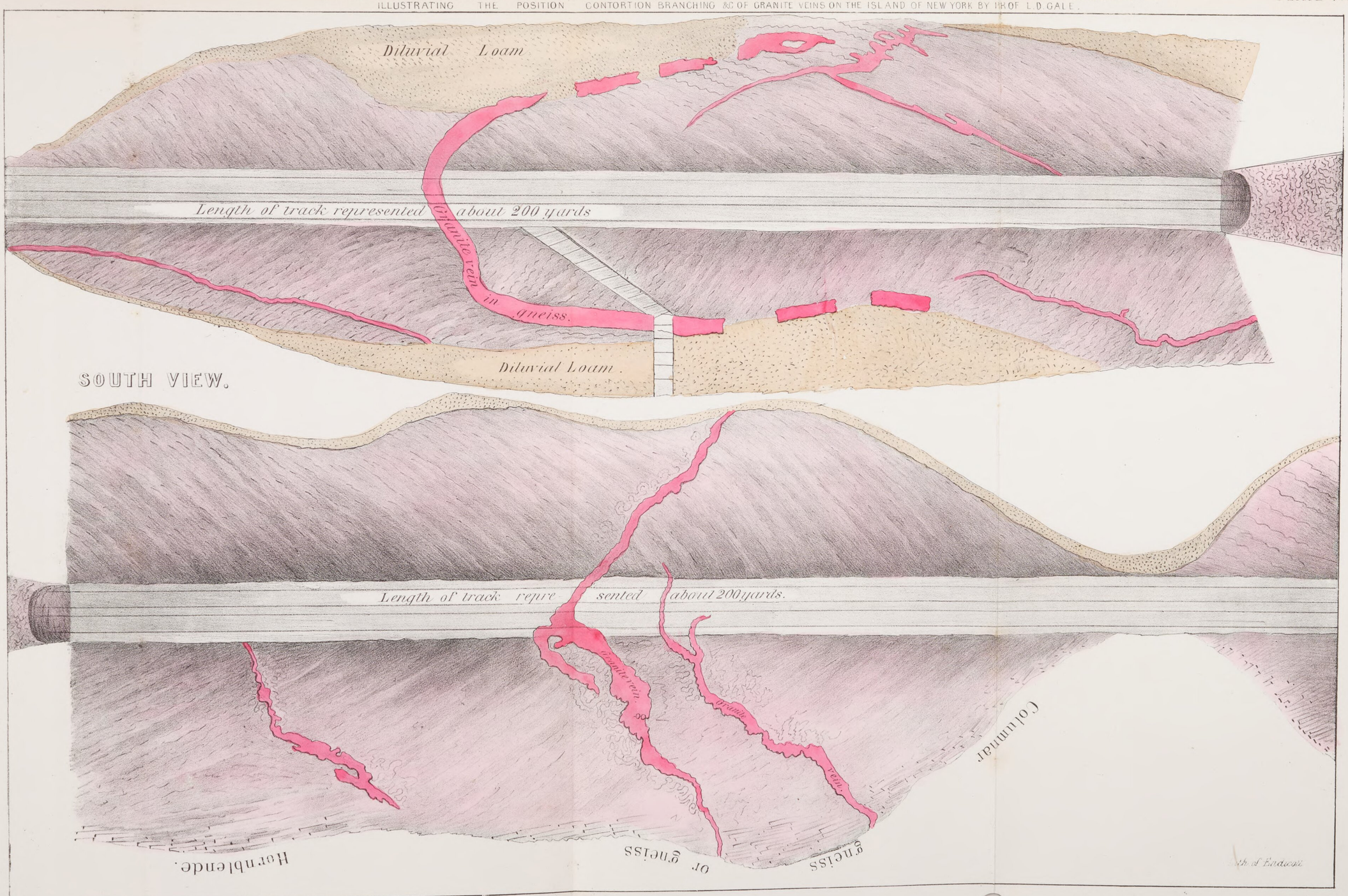


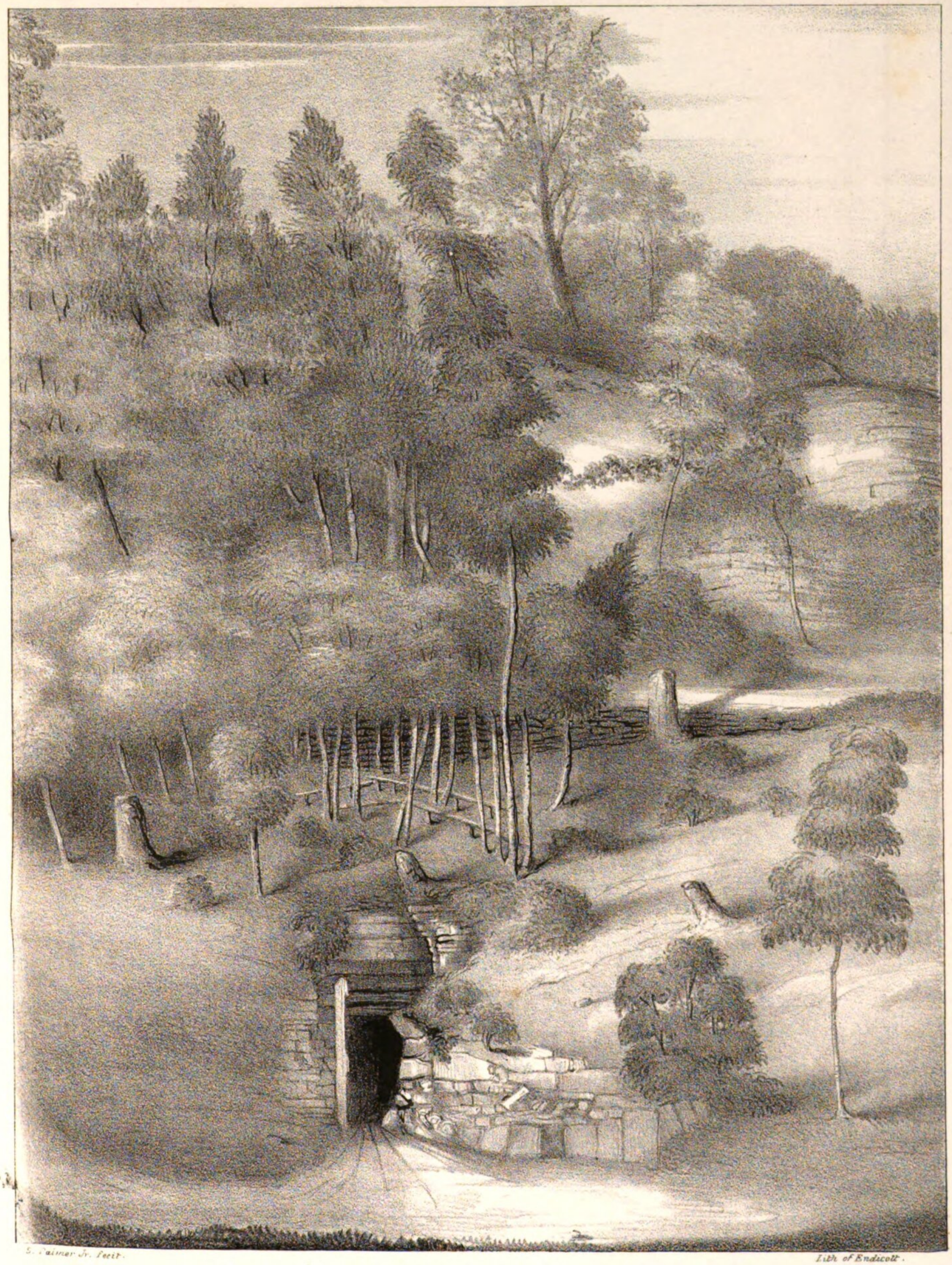


OF THE ILLUSTRATIONS TO PROF. J.W. BAILEY'S PAPER ON AMERICAN BACILLARIA.

VIEW OF THE CUT OF HARLEM RAIL ROAD NORTH OF THE TUNNEL.

ILLUSTRATING THE POSITION CONTORTION BRANCHING &C OF GRANITE VEINS ON THE ISLAND OF NEW YORK BY PROF L.D GALE.





S. Palmer Jr. fecit.

Lith. of Endicott.

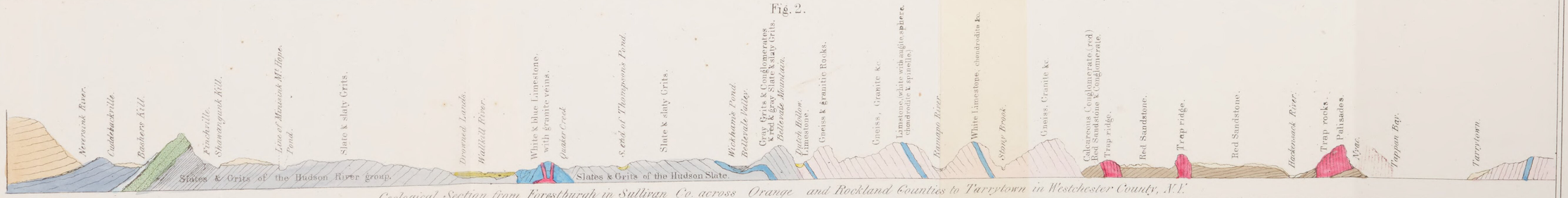
HOWE'S CAVE COBLESKILL N.Y.

Fig. 1.



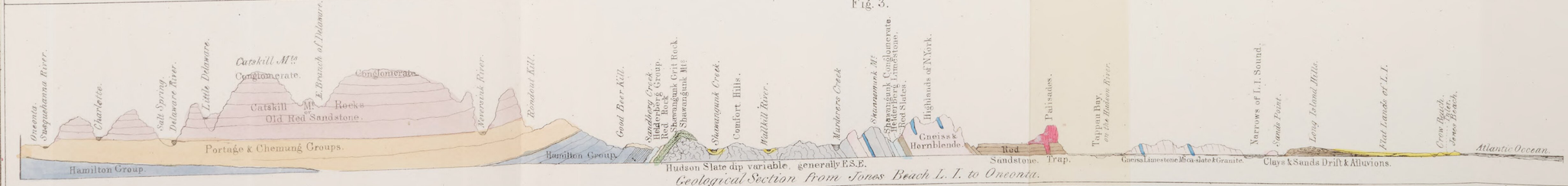
Geological Section from Monticello in Sullivan Co. to the Croton River near Bulls Bridge in Westchester County N.Y.

Fig. 2.



Geological Section from Forestburgh in Sullivan Co. across Orange and Rockland Counties to Tarrytown in Westchester County, N.Y.

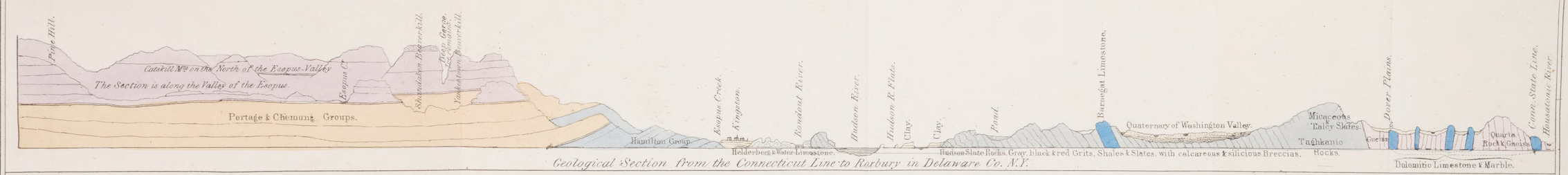
Fig. 3.



Geological Section from Jones Beach L.I. to Oneonta.

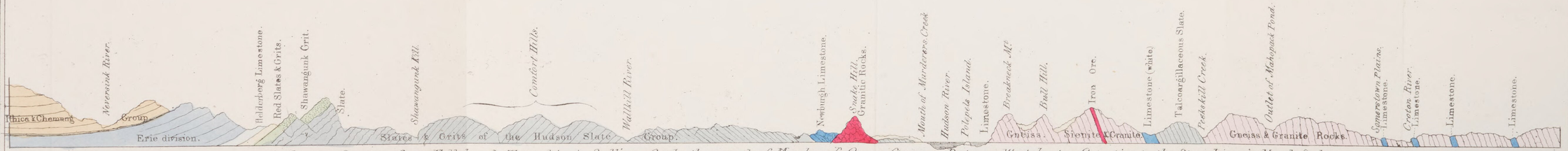
Lith. of Endicott N.Y.

Fig. 1.



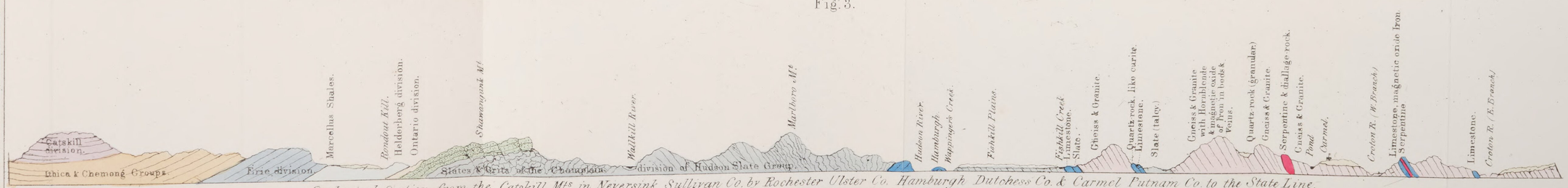
Geological Section from the Connecticut Line to Roxbury in Delaware Co. N.Y.

Fig. 2.



Geological Section from Fallsburgh Township, in Sullivan Co. by the mouth of Murderers Cr. Orange Co. across Putnam Westchester Counties to the State Line in North Salem.

Fig. 3.



Geological Section from the Catskill Mts in Neversink Sullivan Co. by Rochester Ulster Co. Hamburgh Dutchess Co. & Carmel Putnam Co. to the State Line.

Lith. of Endicott N York



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